NASA-TM-108099

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GLOBAL TROPOSPHERIC EXPERIMENT

NASA

GTE/ABLE-3B

(NASA-TM-108099) GLOBAL TROPOSPHERIC EXPERIMENT/ATMOSPHERIC BOUNDARY LAYER EXPERIMENT (GTE/ABLE-3B): CANADA-SUMMER 1990 EXPEDITION PLAN (NASA) 93 p

N93-70423

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Z9/46 0124696

CANADA-SUMMER 1990 EXPEDITION PLAN

ATMOSPHERIC BOUNDARY LAYER EXPERIMENT

(GTE/ABLE-3B)

EXPEDITION PLAN

CANADA - SUMMER 1990

March, 1990

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1.0 INTRODUCTION

The goal of the National Aeronautics and Space Administration's (NASA's) Tropospheric Chemistry Program is to develop an understanding of global atmospheric chemistry and assess the susceptibility of the global atmosphere to chemical change. A major component of the program is the Global Tropospheric Experiment (GTE), which consists of a series of field expeditions to evaluate the performance of new instrumentation under development and to address specific field measurement issues relevant to global tropospheric chemistry. This document will describe the operational plans for the third in a series of GTE mission designated as the Atmospheric Boundary Layer Expedition-3B (ABLE-3B).

The ABLE series of expeditions have the following general scientific objectives: (1) Understanding the processes which regulate the uptake and release of trace gases by surface ecosystems, with particular emphasis on obtaining an improved understanding of factors which influence tropospheric trace gas budgets at the global scale; (2) determining the distribution of photochemically active atmospheric gases in relation to both source /sink characteristics and meteorological transport processes in regions which have been identified as high priority areas for understanding global tropospheric chemistry (see the National Academy of Sciences document, <u>Global Tropospheric Chemistry: A Plan for Action</u>); and (3) development of new approaches for using airborne measurements, integrated with ground and satellite support data, to move toward quantification of atmospheric chemical processes at increasingly larger spatial scales. Three ABLE missions have been completed or initiated. ABLE-1, completed in 1984, was based in Barbados and focused on the chemistry and transport processes over the tropical Atlantic Ocean. ABLE-2A and -2B completed in 1985 and 1987, respectively, studied processes within and over the canopy of the Brazilian Amazon Rain Forest. ABLE-3A, conducted in Alaska during the summer of 1988, represented the first phase of the NASA initiative to study, processes in the northern latitudes.

The ABLE-3B expedition is a joint activity between U.S. and Canadian Researchers. This document, however, focuses upon the U.S. plans and includes those activities closely coordinated and executed in concert with the Canadian research.

2.0 EXPEDITION OBJECTIVES

2.1 <u>General</u>

The ABLE-3B proposes to investigate biosphere-atmosphere gas exchange processes across a climatic gradient from arctic tundra to boreal environments, and to study atmospheric photochemical and transport processes which couple these environments to the global tropospheric chemical system. The proposed research is focused on the sources, sinks and distributions of CH_4, CO, CO_2, NO, NO_2, NO_y, HNO_3, PAN, O_3, selected NMHC, and organic acids in the latitudes

(>50^0N) of Canada. The ABLE-3B measurement program includes (1) ground based and eddy correlation flux measurements of surface exchange of CH_4, CO_2, NO_y, and O_3, with complementary profile data for NO, selected NMHC, and organic acids; and (2) aircraft-based remote sensing and in situ measurements of atmospheric transport and photochemical processes which determine the distributions of the selected gases of interest in the atmospheric boundary layer and free troposphere overlying the Canadian arctic, subarctic, and boreal land, ocean, and ice environments. These studies will investigate the potential importance of variability in trace gas exchange rates and processes over a range of spatial scales from m^2 to 10^4 km^2, an issue critical to the design of future International Geosphere Biosphere Program (IGBP) studies.

The coupling of local/regional surface exchange processes to the regional/global tropospheric chemical system will be studied through a focus on understanding the regional distributions and chemistry of CH_4, CO, CO_2, NO, NO_2, NO_y, HNO_3, PAN, O_3, selected NMHC, organic acids, and aerosols in carefully defined meteorological environments. Based on preliminary model calculations and field measurements obtained during ABLE-3A in Alaska, it is hypothesized that the regions of study are a globally significant source for atmospheric CH_4, a sink for CO_2, and that the mid-summer, unpolluted atmospheric boundary layer in this region will be a NO_x-limited, hydrocarbon-rich system which results in photochemical O_3 destruction.

The primary study and operational sites for ABLE-3B are shown in Figure 2.1-1. The research areas are the Hudson Bay Lowlands (HBL) and a region around Schefferville. The Canadian intensive study area for the Northern Wetlands Project is centered at Lake Kinosheo, approximately 50 km WNW of Moosonee, from which the Canadian aircraft operates. The NASA Electra aircraft, because of its requirements, will operate out of North Bay for the cooperative research in the HBL. During flights to and from the HBL, overflights of the Fraserdale Baseline Air Chemistry Observatory will provide regular opportunities for additional data correlations. The Electra will operate out of Goose Bay for those activities coordinated with NASA ground personnel in the Schefferville area. The NASA ground site in Schefferville will be near the McGill Subarctic Research Station and allow close cooperation with the Canadian researchers there.

The ABLE-3B study sites are located in regions which are expected to be especially sensitive to climate variability. The sites were selected, in part, based on model simulations of possible effects of a "greenhouse gas" induced warming on the surface climate and vegetation distribution in North America. The ABLE-3B will provide "baseline" data on the characteristics of CH_4, CO_2, CO, and O_3 fluxes along existing climatic and ecosystem gradients. These data will provide a basis for the direct measurement of perturbations due to any future climate change. The ABLE-3B data will also provide landscape and regional estimates

GTE/ABLE-3B RESEARCH AREAS
July-August, 1990

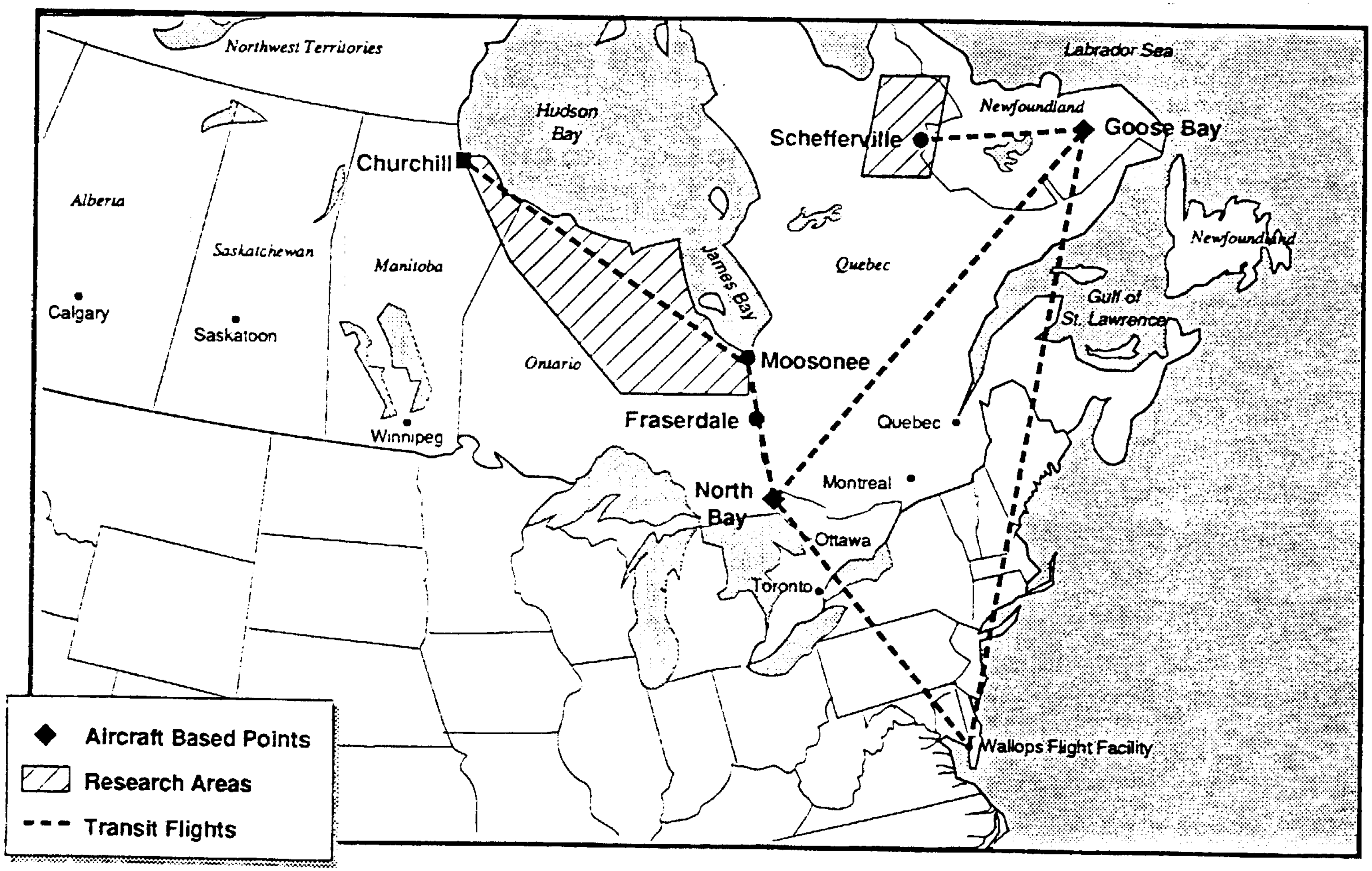


Figure 2.1-1.

of trace gas fluxes which are required for modeling studies for biospheric feedbacks related to climate variability.

The southern Hudson Bay lowland region in northern Ontario is significantly impacted by northward and eastward transport of air pollutants from industrial areas during summer months. The ABLE-3B will investigate the role of pollutant deposition as a potential factor in ecosystem biogeochemistry in both tundra and boreal landscapes. ABLE-3B will characterize atmospheric boundary layer photochemical processes along a chemical gradient from pristine Arctic and Subarctic air to contaminated air masses which have moved across North America from Pacific and Gulf of Mexico source regions.

The ABLE-3B will be conducted as a joint Canadian-U.S. expedition. The Canadian Northern Wetlands (CNW) Study has been organized under the Canadian Institute for Research in Atmospheric Chemistry (CIRAC) and has as its objective a long-term study of the role of the Hudson Bay lowlands in northern Ontario as a source of global tropospheric CH_4. The joint study in 1990 will provide important information on the spatial characteristics of CH_4 distribution within the Hudson Bay region to help focus more process-oriented Canadian studies in future years.

2.2 Specific

The Atmospheric Boundary Layer Expedition (ABLE-3B) proposed for the summer months in 1990 will address the following issues:

1. What are the spatial distributions of CH_4, CO, CO_2, NO, NO_2, HNO_3, NO_y, PAN, O_3, NMHC, and organic acids in the remote high latitude (>50°N) regions of North America? How do the spatial scales of variability measured by aircraft sampling relate to potential biospheric source and sink processes characterized by the Canadian and ABLE-3B ground-based investigations.

2. How does synoptic-scale meteorological variability interact with surface exchange processes and with atmospheric photochemical processes to influence trace gas distributions in the planetary boundary layer and free troposphere over Canadian tundra and boreal environments? Because these regions are characterized by complex synoptic-scale interactions in summer months, it is anticipated that this study will encompass a range of air mass types from pristine Arctic air to polluted Gulf of Mexico air.

3. What specific sources and/or sinks of CH_4, CO_2, NO_x, O_3, and other atmospheric gases are identified? How do these sources and sinks relate to climate variables? What conclusions can be drawn concerning future rates of change in Arctic air chemistry in the event a climate warming begins during the next several decades?

4. ABLE-3B will be an important contribution to understanding the potential role of the major pool of soil carbon

CO_2 under present and future climatic conditions. This expedition will also provide an assessment of the factors that influence atmospheric photochemical processes in the summer high latitudes and the utility of ground-based atmospheric monitoring for determining trends in global atmospheric CH_4, CO_2, and O_3.

3.0 MEASUREMENTS

3.1 Airborne

GTE/ABLE-3B airborne measurements will be made aboard the NASA Wallops Flight Facility Lockheed Electra. Aircraft characteristics and the location of experiments and general space allocation aboard the aircraft are in Appendix A. Specific details of experiment/aircraft interfaces are to be worked between the principal investigator teams and the Aircraft Operations and Experiment Integration Manager. Aircraft integration and unloading schedules are discussed in Section 7.0.

The atmospheric species and scientific parameters to be measured to achieve the ABLE-3B science objectives are listed in Table 3.1-1 along with measurement system characteristics and Principal Investigators. Appendix B contains brief descriptions of the measurement techniques. The parameters describing meteorological, navigational, and other aircraft characteristics to be measured aboard the aircraft are presented in Table 3.1-2. These measurements are to be provided to all investigators by the GTE Project.

3.2 Ground Site Measurements

The ground site studies will include measurements from two towers (see section 4.2) and surface chambers. Measurement system characteristics and Principal Investigators are listed in Table 3.2-1 for the ABLE-3B studies and Table 3.2-2 for a NASA collaborative program, the Biospheric Research: Emissions from Wetlands (BREW) Studies (see section 4.2.1). Appendix B also contains brief descriptions of these techniques.

4.0 EXPERIMENT DESIGN

The expedition will utilize ground-based, aircraft, and satellite measurements to study processes contributing to trace gas variability over a range of spatial scales. The ABLE-3B joint (Canadian-U.S.) science team has developed an experimental design to provide flexibility for conducting scientific operations over a variety of weather conditions. Scientific goals require intensive studies of the atmospheric mixed layer for biosphere-atmosphere trace gas exchange measurements. The investigation of the large-scale impact of biospheric emissions requires sampling of the mixed layer and free troposphere on a regional basis. Finally, the expedition has planned for special studies of biomass burning impacts on regional air chemistry if fires occur during the study period.

TABLE 3.1-1: GTE/ABLE-3B MEASUREMENTS
AIRCRAFT SAMPLING

SPECIES	SAMPLING RATE	METHOD	PRINCIPAL INVESTIGATOR
O_3	1 - 10 Hz	O_3-NO Chemiluminescence	G.L. Gregory, NASA Langley Research Center
CO, CH_4	1 - 10 Hz	Diode Laser Absorption	G.W. Sachse, NASA Langley Research Center
NO, NO_2, NO_y	2 Min.	Laser Induced Flourescence	J.Bradshaw, Georgia Institute of Technology
Turbulent Flux of CO, O_3, and H_2O	10 - 20 Hz	Diode Laser Absorption, Chemiluinescence, and Lyman alpha	J.Ritter, NASA Langley Research Center
Aerosol size Distribution	1 - 30 sec.	0.5 to 8 mm Diam. forward scattering spectromenter 0.12 to 3.12 mm Diam. active scattering spectrometer	G.L. Gregory, NASA Langley Research Center
Hydrocarbons (to C_6), CO, CH_4 Terpenes & Halocarbons	5 - 10 hr^{-1}	Grab Samples/GC	F.S.Rowland University of Cal.-Irvine
Aerosol Composition	1 - 5 hr^{-1}	Filter Pack/IC	R.W.Talbot, University of New Hampshire
Gas Phase Organic Acid (formic, acetic, pyruvic)		Aqueous scrubber/IC	
Nitric Acid		Aqueous scrubber /IC	

TABLE 3.1-1. GTE/ABLE-3B MEASUREMENTS (cont'd)

AIRCRAFT SAMPLING

SPECIES	SAMPLING RATE	METHOD	PRINCIPLE INVESTIGATOR
PAN, PPN, CCl_4, CH_3ONO_2,	6 min.	GC/EC	H.B. Singh, NASA Ames Research Center
Aldehyde & Ketones	12 min.	GC/FID	
Remote Vertical Profile of O_3	0.1 Hz	DIAL (Differential Absorbtion Lidar)	E.V. Browell, NASA Langley Research Center
Remote Vertical Profile of Aerosols	5 Hz	DIAL	

TABLE 3.1-2: METEOROLOGICAL/NAVIGATIONAL BASE DATA

(Responsible Individual: J.D. Barrick, NASA Langley Research Center)

Parameter	Range	Accuracy	Instrument Type
Air Temperature	± 50°C	± 0.5°C	Platinum Resistance
Water Vapor Dew Point	-75° to +75°	±0.2°C	Frost Point Hygrometer (3 stage)
Water Vapor Dew Point	-30° to +50°C	± 0.5°C	Frost Point Hygrometer (2 stage)
Surface Temperature	-30° to +80°C	± 0.5°C	Bolometric Radiometer
Static Pressure	0-15 psia	± 0.3%	Capacitive Sensor
Dynamic Pressure	0-3 psid	± 0.3%	Capacitive Sensor
Pressure Altitude	0-30,000 ft	± 0.25%	Capacitive Sensor
Horizontal Position	±90° latitude ±180° longitude	2 nm	Omega Navigation System
Horizontal Position	±90° latitude ±180° longitude	0.5 nm/hr	Inertial Navigation System (INS)
Aircraft Pitch and Roll Angle	±90°	±0.2°	INS
Horizontal Winds	100 kts, 360°	5 kts, 5°	INS
Aircraft Ground Track	360°	±1°	INS
Time	Day:HR:MIN:SEC	1 msec	GOES Retransmitter NBS Time
Solar Ultraviolet Radiation (nadir and zenith)	295 - 385 nm	±2%	Selenium Barrier-Layer Photoelectric Cell

Table 3.2-1: GTE/ABLE-3B Measurements

GROUND-BASED SAMPLING

SPECIES/PARAMETER	SAMPLING RATE	INSTRUMENTATION	LOCATION	P.I.
Eddy Correlation Flux:				
O_3	>1 Hz	Dasibi	6m, 30m tower	S.C. Wofsy Harvard Univ.
CO_2	>1 Hz	IR Absorption	6m, 30m tower	
THC	>1 Hz	FID	6m, 30m tower	
CH_4	>1 Hz	GFC	6m, 30m tower	
NO_y	>1 Hz	Au Converter/Luminol Chemiluminescence	30m tower	
Heat, Humidity, & Momentum Budgets	>1 Hz	Fast response dry- and wet-bulb temperature, hygrometers, and anemometers	6m tower (2 levels) 30m tower (4 levels)	D.R. Fitzjarrald SUNY-Albany
In Situ Profiles:				
NO	1 Hz	Chemiluminescence	30m tower	S.C. Wofsy Harvard Univ.
NO_2	1 Hz	Photolytic converter/	30m tower	
HNO_3 and Organic Acids	20-30 min.	Aqueous scrubber/IC	6m, 30m tower	R.W. Talbot U. New Hampshire
Surface Measurements: CH_4: Ambient Flux Production Rate	8-10 min.	GC-FID	surface chamber Incubation	P.M. Crill U. New Hampshire
Radiation (Total solar and PSA)	30 sec.	Eppley and net radiometers, pyronometers	Swing-set (marsh site)	D.R. Fitzjarrald SUNY-Albany
Soil Conditions: Temperature, moisture, heat flux	10-60 sec.	temp. probe, Gypsum block, Heat flux	Marsh Site (several depths)	D.R. Fitzjarrald SUNY-Albany

Table 3.2-2: Measurement Summary for NASA-BREW Program

Principle Investigator	Activity
Vic Klemas (Univ. of Delaware)	Above and belowground biomass, remote sensing reflectance measurements, dissolved CH_4 soil profiles,, soil characterization - organic layer thickness, depth to bedrock
Chris Martens (Univ. of N. Carolina)	Radon tracer studies on tower, isotopic signature of CH_4, seasonal CH_4 porewater profiles, plant gas-transport flux studies, C-N soil and plant analysis
John Dacey (Woods Hole Oceanographic Institute)	Plant transport of gas & belowground biomass studies in differnt plant species, DMSP and DMS cycling
Gary King (Univ. of Maine)	Methane oxidation studies algal photosynthesis effects of CH_4 emission, oxygen profiles, root associated oxidation
Mark Hines (Univ. of New Hampshire)	Sulfur (DMS, H_2S,CS_2, MeSH, COS) flux from various wetland communities
Gary Whiting (STX, NASA Langley)	Net CO_2 exchange - remote sensing relationship in tundra & fen communities, seasonal and diurnal
Ramona Travis (NASA-Stennis)	Remote sensing - airborne & satellite based, AEM profiling of subsurface soil features

4.1 Aircraft Mission Scenarios

The following paragraphs describe a variety of general flight scenarios appropriate to the mission objectives. These nominal flight plans serve as a "menu" for the development of daily flight operations in the field. The project meteorologist will daily advise the science team of weather conditions. Missions will generally be developed by selecting a flight plan from the menu with appropriate modifications for weather and specific science requirements.

Generalized aircraft mission scenarios developed by the science team (see Figure 4.1-1) can be briefly described as follows:

1. Flux Measurements - These missions will be focused on the determination of CH_4, CO, and O_3 flux through the atmospheric mixed layer. In ABLE-3B the airborne flux measurement program will be closely coordinated with the ground-based and airborne flux measurement program being conducted by the Canadian Northern Wetlands Project in the southern portion of the Hudson-James Bay Lowlands near Moosonee. In the Shefferville, Quebec, region the ABLE airborne flux measurement missions will use the ABLE ground-based flux measurement sites as focal points. A more in-depth look, than that shown is Figure 4.1-1(b), at potential flight patterns for flux measurements in this joint mission is contained in Appendix C.

2. Regional Biospheric Impact Studies - These missions are designed to determine the influence of surface exchange processes on the large-scale distribution of CH_4, CO, O_3, NO, NO_2, NO_y, NMHC, organic acids, HNO_3, PAN, and aerosol chemical species. Three general approaches to studying Regional Biospheric Impacts (RBI) are:

(a) Land-to-Sea Gradient Studies. In these flights the chemistry of the atmospheric mixed layer and overlaying free troposphere will be sampled along a gradient from oceanic (Hudson-James Bay or the North Atlantic) to continental environments (Figure 4.1-1(c)). The combination of flux and distribution measurements along these gradients can characterize source/sink processes for a wide array of trace gas and aerosol chemical species. Free tropospheric measurements provide an indication of coupling processes which link the biosphere to the large-scale regional circulation.

(b) Forest-Tundra-Wetland Comparisons. Flight scenarios will be designed to provide for sampling in the mixed layer over at least three general high latitude environments. In ABLE-3B there should be opportunities to conduct extended sampling over tundra (northern Hudson Bay Lowlands), open peatlands (Hudson-James Bay Lowlands), boreal forest (North Bay area), and mixed wetland-woodland (Shefferville area). Sampling these diverse terrains at

ATMOSPHERIC BOUNDARY LAYER EXPERIMENT-3B

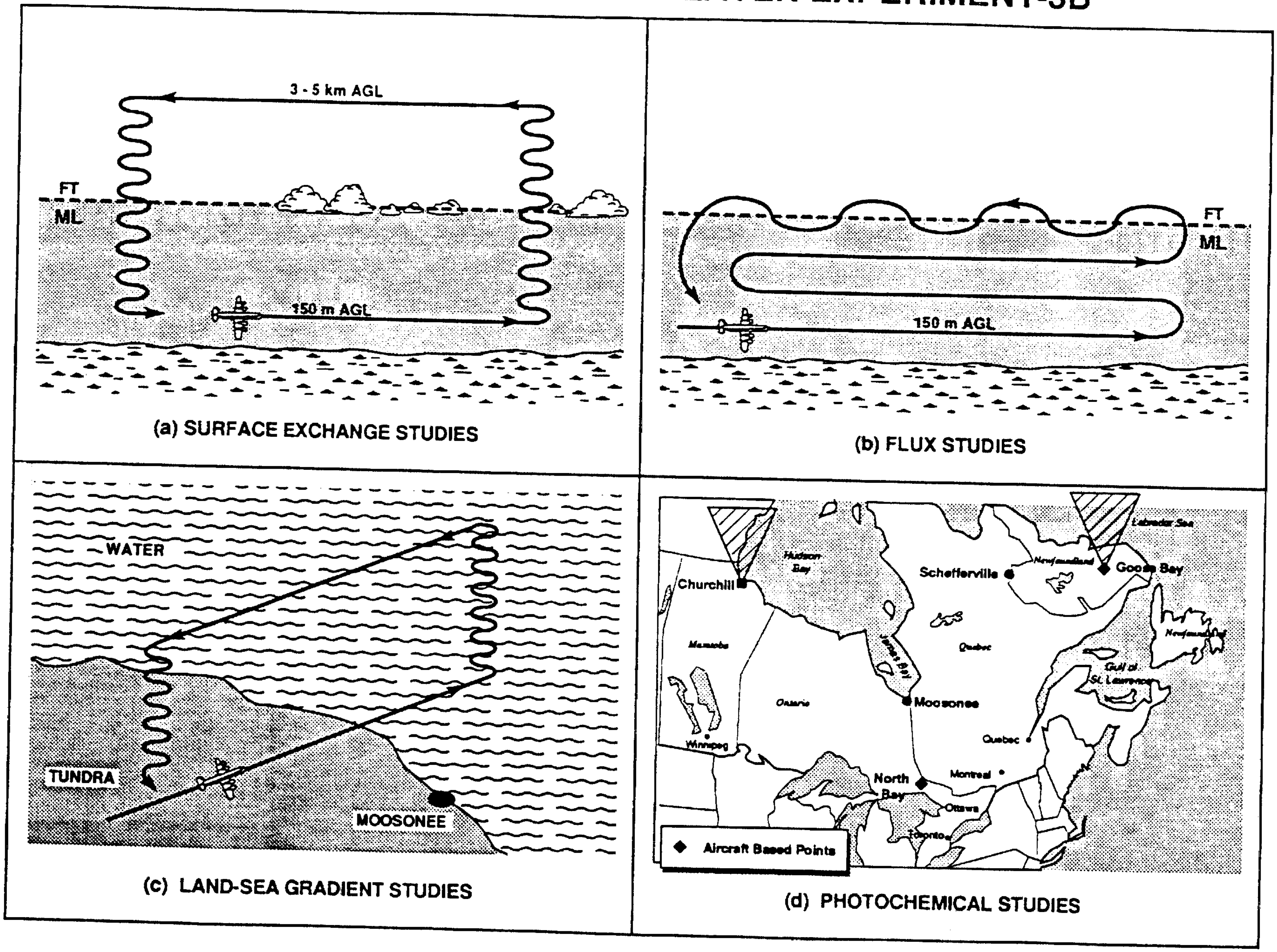


Figure 4.1-1: Generalized flight patterns for an ABLE-3B.

large-scale should provide insight to their roles as sources and/or sinks for various trace gases.

(c) Arctic Air Characterization - The objective of Arctic air characterization is to define the composition of "background" air which has had minimal contact with biospheric sources and/or sinks of trace gas and aerosol species. Particular emphasis will be placed on sampling the Arctic mixed layer and free troposphere immediately prior to its passage over the northern Hudson Bay Lowlands and the Schefferville region (Figure 4.1-1(d)).

3. Climate Gradients - Climate-related parameters (soil temperature, soil moisture, permafrost, etc.) are critical factors determining the flux of CH_4 and other trace gases from surface environments. The Hudson-James Bay Lowlands provides an opportunity to sample trace gas emissions from peatland environments along a climate gradient from warmer regions in the south to the colder, permafrost environments near Churchill, Ontario (Figure 4.1-1(a)). These flights will focus on surface exchange processes and their influence on the chemistry of the mixed layer along this climatic gradient.

4. Fire Impacts - The ABLE-3B study area is a region with frequent summer forest fires. Since the issue of biomass burning impacts on the global troposphere is of considerable importance, the science team has planned flights to take advantage of opportunities to sample any large-scale emissions which may impact the ABLE study areas. The UV-DIAL system on the NASA Electra enables real-time identification of "haze" layers associated with downwind transports of forest fire emissions, and guides the in situ sampling. These studies could be of particular importance due to the relative paucity of data on aged biomass burning emissions.

4.1.1 Allocation of Flight Hours

The ABLE-3B has 130 flight hours for the entire mission. A tentative plan for allocation of these hours was developed by the science team (Table 4.1). The final decision on specific missions and allocation of flight resources will be made by the science team and project staff during the expedition. Many factors (e.g., weather, fire activity, "unexpected" scientific discoveries) can be important in determining how to best use flight resources.

4.2 Ground-Based Measurements

The primary location for ground-based measurements by NASA will be near Schefferville. Marsh (or bog) and boreal forest sites will be instrumented for the two major components of the ground studies: (1) flux measurements using chamber techniques and (2) flux and ambient concentration measurements using a micrometeorological tower. These techniques are intended to be complementary. The chamber methods give information on the smallest scales (≈ 1 m^2) and provide indications about the climatological factors (e.g., soil temperature, moisture) which influence emission/deposition

TABLE 4.1: TENTATIVE ALLOCATION OF ELECTRA FLIGHT HOURS

	Hours
Test Flights and Tower Fly-by	15
Transit Flights*	
Wallops to North Bay	5
North Bay to Goose Bay	6
Goose Bay to Wallops	12
Flux Measurements	32
Land-Sea Gradients	15
Forest-Tundra-Wetlands Gradient	15
Arctic Air Characterization	15
Long-Range Transport	15

* All flights involving transit between bases will be considered research data flights and will include vertical profiles.

rates. The micromet techniques provide flux information for larger areas (≈10^5 m^2) and give a direct measure of gas exchange by turbulent transport and data on diurnal and vertical variations of trace gas concentrations.

Direct measurements of surface fluxes of CH_4, CO_2, O_3, NO_x, NO_y, and total hydrocarbons (THC) are envisioned. Eddy-correlation flux measurements will be made from two tower sites. A 6m tower will be erected at a marsh site, and a 30m tower placed at a forest site. The instrumentation in each tower is noted in Figure 4.2-1. The objective using the smaller tower is to characterize only the marsh environment, the surface "footprint" being totally confined to the wetland area. The larger tower at the boreal forest site, extending nearly 3 times the canopy height, provides a much larger "footprint" encompassing the more patchy landscape.

Gradient measurements of wind speeds and wet-and dry-bulb temperatures will be made at two levels on the small tower and at four levels on the large tower. These measurements are used for making flux estimates for trace gases for which no rapid-response sensor is available and for determining the transport terms in turbulent budgets of heat, momentum, and moisture.

A primary emphasis in flux measurements is the evaluation of techniques for "scaling up" enclosure, tower, and airborne results to a regional scale flux. These techniques, involving the understanding of scales of variability in trace gas surface exchange processes, require accurate mapping of the ecological characteristics of each study area. It will be particularly important to have quantitative information on the distribution of vegetation types, open water, and, if possible, surface soil properties along the flight tracks of the NASA aircraft and in adjacent areas which influence the air masses being characterized. The results of other NASA programs and of similar Canadian research using remote sensing techniques to characterize the distribution and areas of major vegetation and open water (such as aircraft photography, LANDSAT, and AVHRR imagery) will be used in the investigation of "scaling up" the ground-based flux measurements for comparison with those made by the Electra.

4.2.1 Surface Studies of Biogenic Gas Exchange

A group of investigators, supported by the NASA Life Sciences Division, Biospheric Research Program, will be providing a collaborative effort of surface measurements (Table 3.2-2) which complement the GTE/ABLE and Canadian efforts. This team of scientist has a primary goal to understand the processes involved in the exchange of biogenic gases between wetland environments and atmosphere (**BREW** - **B**iospheric **R**esearch: **E**missions from **W**etlands). The research effort is guided by the following strategy: determination of magnitude, transport mechanism, and controlling variables in biogenic gas exchange; establishment of linkages between inventoried parameters (i.e., vegetation type, climate) and factors controlling gas emission; and incorporation of these

ABLE-3B TOWER MEASUREMENTS/SCHEFFERVILLE

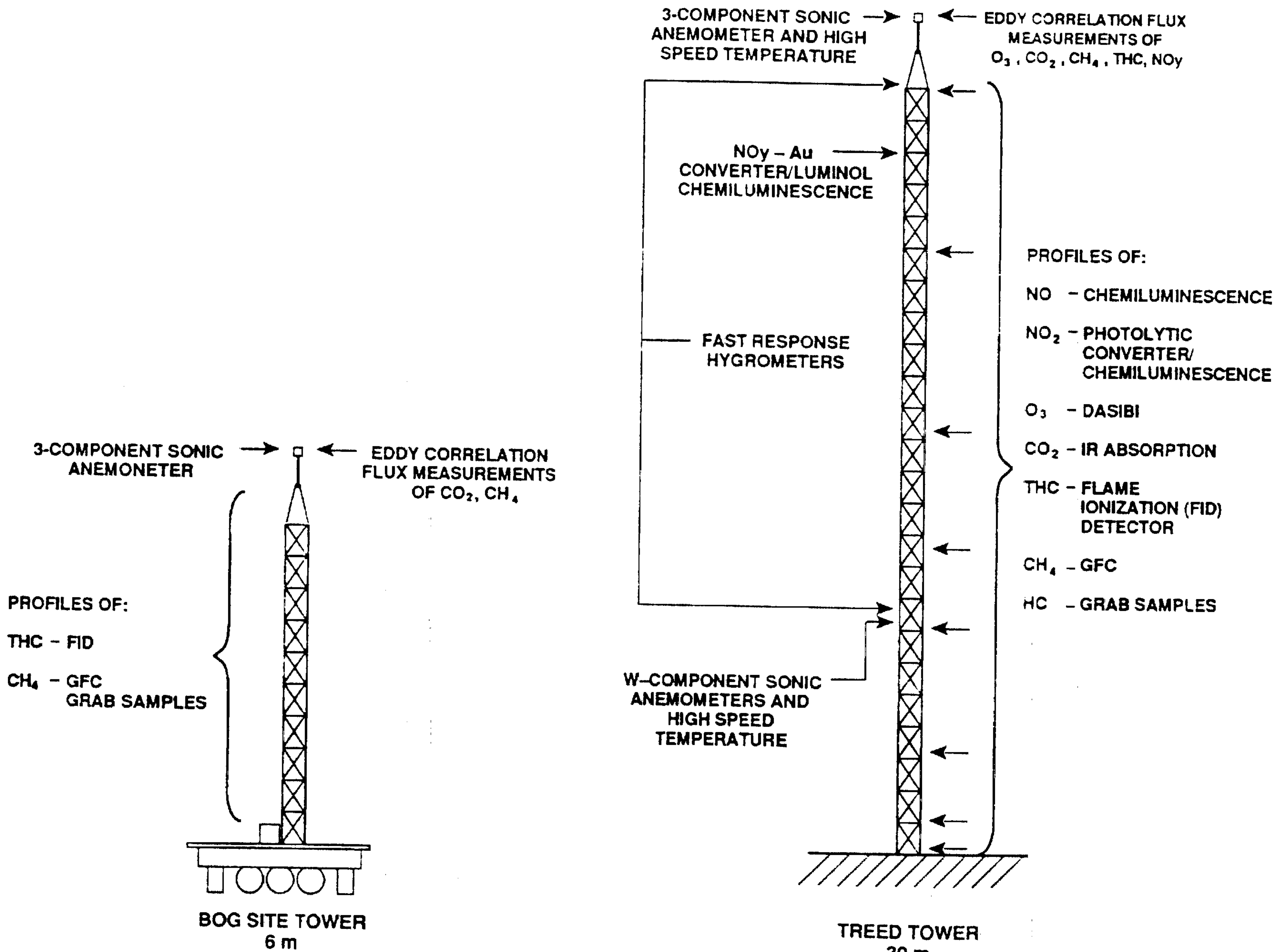


Figure 4.2-1.

linkages into an landscape inventory utilizing remote sensing technology to obtain areal estimates of exchange.

The BREW project will center most of its efforts in the vicinity of Schefferville at the NASA fen site with a concentrated effort during a 3 week period near the end of July and the beginning of August. Some research efforts will also be involved with the Canadians near Moosonee/Kinosheo Lakes. The investigations will encompass a physical study of the wetlands using radar, electromagnetic profiling detectors, and coring for characterization of subsurface biomass and soil structure. Dissolved gas concentrations, emissions, isotopic gas signature, above and below ground plant biomass, photosynthetic activity and microbial oxidation of gases are a few of the correlated measurements planned during the field mission to determine the mechanism and control of gas exchange. Areal estimates of CO_2, CH_4, radon and sulfur emissions will be compared to tower measurements where applicable. Remote sensing investigations of subsurface structure and vegetation cover will interact with and complement the GTE/ABLE and Canadian plans to obtain the necessary data for extrapolation of trace gas exchanges over large geographic areas. Details of each investigators experimental plans can be found in Appendix B.

4.2.2 Ground Site Location/Description

The ABLE-3B Ground Based Research Facility (GBRF) will be located approximately 8 miles (13km) northeast of Schefferville, a small town in north-central Quebec, Canada. The area is representative of the subarctic, boreal woodlands and peatlands of the Labrador Trough region, a globally significant ecosystem. The map of Figure 4.2.2-1 provides an overview of the area and locates major components of our research activities.

Note that the topography of the Schefferville area leads to a preferred wind direction along the valley axis during some synoptic conditions. Because of the importance of the boundary layer wind direction to the upwind fetch seen at the study sites, the four Portable Automated Mesonet (PAM) stations and radiosondes will provide data necessary to analyze the ridge channeling effect.

Two study sites were selected; a wetland site, from which methane emissions are likely to dominate; and a lichen-treed site, where ozone deposition and turpene emission are expected to be important. An instrumented tower at each site will provide the capability of obtaining a time series of data extending over the two month growing season. Continuous power at each site will be provided by generator. A schematic of the two-site layout (Figure 4.2.2-2) identifies the major site operations, located downwind of the instrumented towers to minimize contamination of the measurements. Platforms and boardwalks will protect the fragile ecosystem and allow movement over marsh areas. Sampling platforms will be utilized for enclosure chamber studies. The operational center and lodging facilities will be located at the McGill Subarctic Research Station in Schefferville. Average climatic

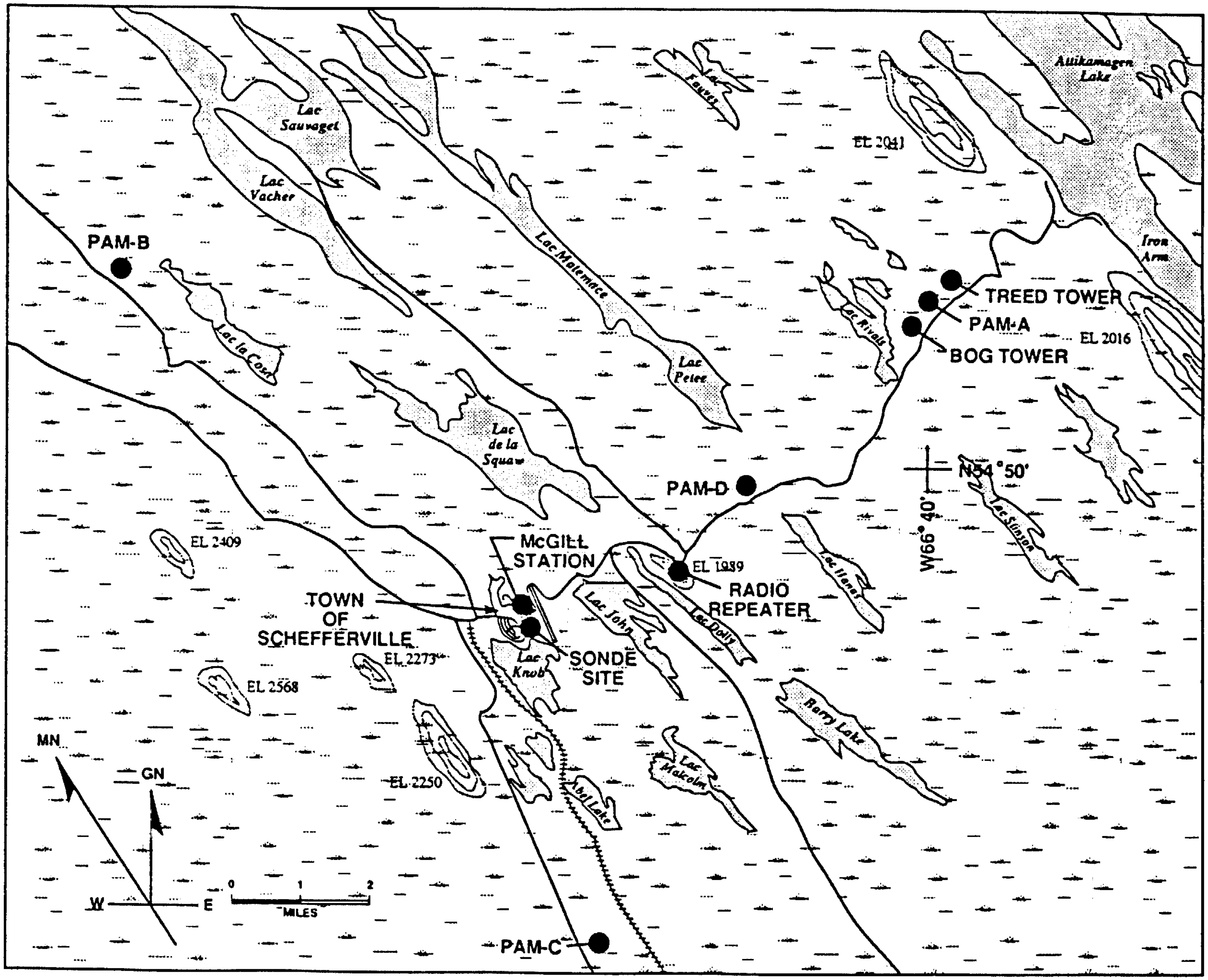


Figure 4.2.2-1. Ground-based research site locations near Schefferville

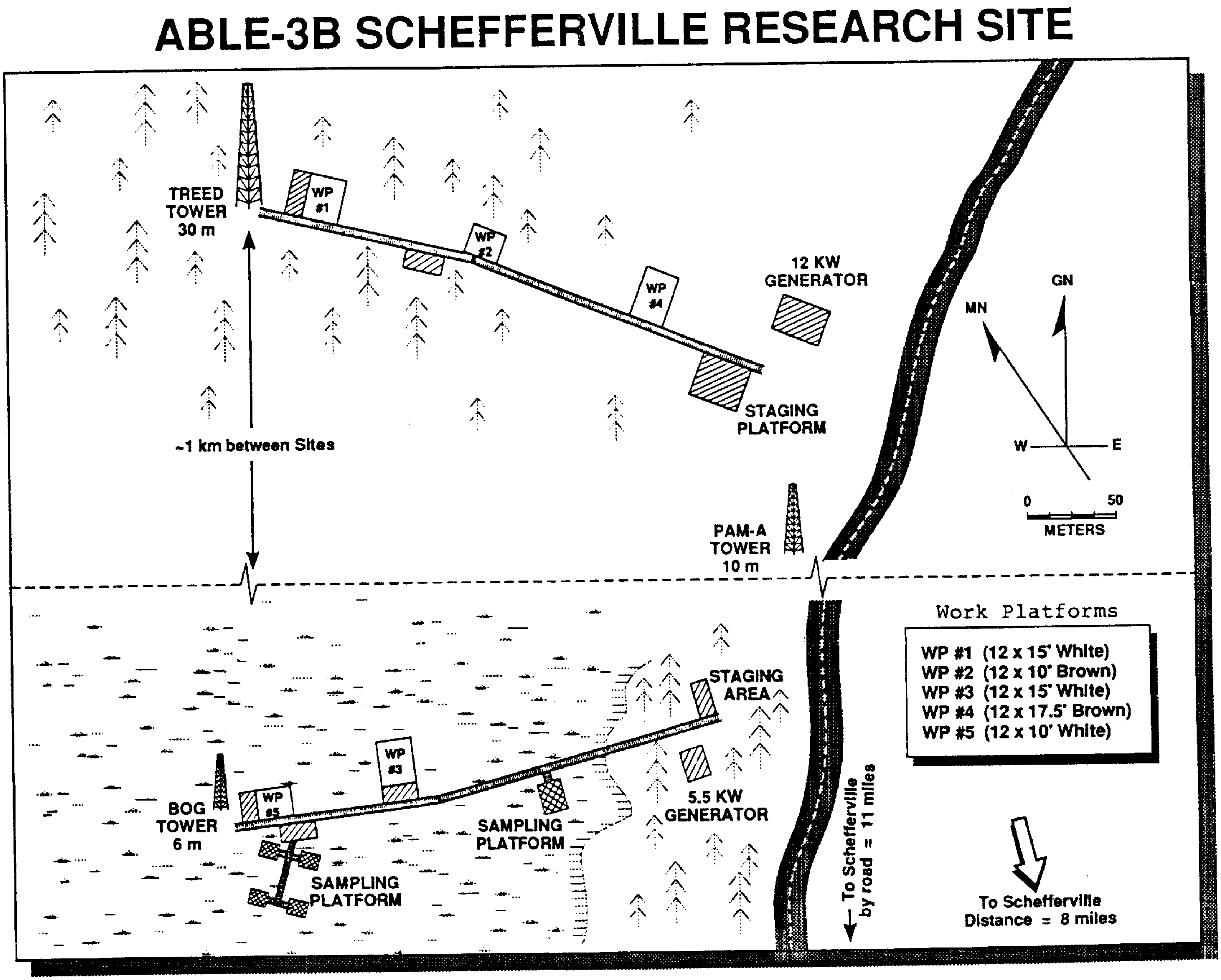


Figure 4.2.2-2. Layout of the two ground sites (schematic)

parameters of interest for the Schefferville area and information on the McGill Subarctic Research Station intended to assist study participants in planning and logistics are contained in Appendix D.

4.3 Meteorological Support

Meteorological support will be provided by project meteorologist stationed with the aircraft (i.e. North Bay and Goose Bay, Canada) and at NASA's Langley Research Center (LaRC). LaRC will act as the central point of data reception, storage, and re-broadcast of information to the field sites. LaRC generated products, including soundings, upper air analysis, and time-height cross-sections will be automatically faxed to the remote sites at 02 and 14 UTC. In addition, the LaRC database will be accessed on an as needed basis to augment the locally available surface hourlys and soundings. Finally isobaric trajectories from the Atmospheric Environment Service (AES) will be available 2 times daily to aid in air mass type identification.

GOES and METEOSAT imagery will be received in Canada thru the portable Digital Weather Information Processing System (DWIPS) that will be set up at the operations center. The system will receive half hourly high resolution imagery in a digital format and will be able to store and animate three days worth of data.

Weather briefings will be given at each science team meeting and a final briefing including flight crew, aircraft mission manager, and mission scientist will be conducted just prior to take off. An in-depth meteorological analysis, including isentropic trajectories, mission summaries, and relevant charts and other products will be transmitted to all PI's within 90 days after the completion of the mission.

4.4 Communications Plan

The ABLE-3B communication plan is designed to meet (1) Emergency, (2) Mission Planning, and (3) Operational Communication needs between the U.S. elements of the Expedition. In addition, routine communication for planning and information exchange with Canadian field components are included. Routine telephone and FAX communications will be available between the various operational centers. The NASA Electra will have aboard a 166 MHz radio transceiver for communicating with the ground research sites. The Schefferville ground research operation will utilize 2-way radios linked through an existing repeater to communicate between research tower locations and the McGill Subarctic Research Station. Hand held radios will be available at each tower location for field communications.

5.0 DATA MANAGEMENT

5.1 Data Handling and Archiving

GTE/ABLE-3B measurements are listed in Tables 3.1-1, 3.1-2, and 3.2-1. The investigators identified are responsible for acquiring, processing, certifying and reducing the data from their instruments. Specific procedures for data handling and initial publication of results are defined by the ABLE-3B Data Protocol as described under Section 5.2. The data shall be converted to data products as described in Section 5.3 and submitted to the GTE Data Manager in accord with the Data Protocol. Data products submitted will be incorporated into an expedition archive to be released to the public domain following the proprietary data period. The data products and publication schedule derived from the data protocol is shown in Section 7.0.

5.2 Data Protocol

The purpose of the Global Tropospheric Experiment data protocol is to: (1) encourage an orderly and timely analysis, interpretation, and publication of the data obtained during integrated field expeditions in pursuit of the goals of the NASA Tropospheric Chemistry Program; (2) foster collaboration among each team of expedition investigators, thereby enriching the scientific interpretation of the data obtained from single and ensembles of instruments; (3) establish a procedure to produce an integrated expedition archive that will serve as a central repository of data products to be released to the public domain.

The specifics of the GTE/ABLE-3B data protocol and the associated data products and publication schedule as developed by the expedition science team are detailed in sections 5.2.1 - 5.2.5, 5.3, and 5.4.

5.2.1 Data Certification

The investigators are responsible for the performance of their instruments and for the initial analysis, interpretation, and publication of the data obtained by their instruments. Only certified data products shall be submitted to the GTE Project Office for inclusion in the data archive. The certification process includes editing, conversion to engineering units and verification that the data are ready for release to the public domain.

5.2.2 Proprietary Rights

The data of each investigator is proprietary until release of the archive to the public. Archive release for ABLE-3B is scheduled for 21 months following expedition completion. During the proprietary period, unpublished data of another investigator may not be used in a presentation or publication nor share with others without the consent of that PI.

5.2.3 Data Investigation Plans

5.2.3 Data Investigation Plans

Collaborative as well as individual investigations are encouraged. The Project Scientist will serve as the interface between investigators, science team, and project personnel to foster cooperative activities and keep all science team members informed of the status of proposed and ongoing investigations. To assist in this planning process, the title, description, and participating investigators of a proposed investigation shall be forwarded to the Project Scientist during the formative stages of the investigation.

5.2.4 Publication Products

Early and comprehensive publication of results of the expedition is a primary objective of the Science Team. Each principal investigator is responsible for producing publication products in support of the following publication plan and on the timetable defined by the Data Products and Publication Schedule (see Section 7.0). Until archive release, publication of GTE/ABLE-3B expedition data shall be restricted to those products defined herein.

5.2.4.1 Conference Presentation

Initial oral presentations of selected results by the investigators and the project will be presented together at an appropriate conference. No advance presentations shall be given prior to the selected conference. The ABLE-3B Science Team selected the 1991 Spring AGU Meeting. Copies of abstracts shall be sent to the GTE Project Office at time of submittal.

5.2.4.2 Geophysical Research Letters

ABLE-3B principal investigators will have an opportunity to publish preliminary data analysis results in GRL. Publication plans will be formulated at a science team meeting to be held in conjunction with the Spring 1991 AGU meeting. Publication articles will be submitted in July 1991. Details of the submission process will be determined at the AGU Science Team Meeting.

5.2.4.3 Journal Special Issue

All investigators are expected to submit detailed, comprehensive data analysis papers for a special issue of an appropriate journal. The issue will contain (a) an overview paper and (b) science papers. The overview paper will be authored by Program and Project personnel and the science papers will be contributions from each of the investigator teams. Collaborative papers between investigator groups are encouraged. A statement concerning the availability of the data from the GTE Archive should be included with each paper. Final manuscripts of each paper are to be submitted to the journal with copies to the GTE Project Office 18 months following expedition completion.

All data of potential interest to the scientific community, in addition to data used to generate the publication products, should be certified, reduced to final numbers, and forwarded to the GTE Data Manager for incorporation in the expedition data archive by the first day of the month of the data workshop. Guidelines and instructions for producing and submitting data products to the archive are provided in Section 5.3.4, Archived Products. For information pertaining to archival submittal procedures, call Joseph W. Drewry at (804) 864-5842 or FTS 928-5842, or address written inquiries to:

J.W. Drewry, GTE Data Manager
MS 483
NASA Langley Research Center
Hampton, Virginia 23665-5225

5.3 Data Products

5.3.1 Real-Time and Quick-Look Data Products

Real-time data products will be used only for instrument evaluation and mission planning. These data products are not intended to be distributed nor archived. Real-time data products to made available during aircraft missions are listed in Table 5.3.1-1. These parameters will be provided on monitors and will not be produced on hardcopy. Five-second "picks" of selected base data parameters will be printed during the mission for quick-look availability. The data will not be distributed post flight.

Meteorological data support is presented in section 4.3. Products of interest to the Schefferville ground site will be transmitted to the facsimile transceiver at the Schefferville Operations Center at McGill Subarctic Research Station.

Real time products available at the Schefferville Remote Site will be entered in a daily log. Meteorological parameters available at the Remote Ground Site and at Schefferville will be included. These data will be used to plan ground site operations but will not impact flight mission planning.

Quick-look data products are intended to be used by the investigators during the field to evaluate instrument performance and assist mission planning. The basic product will be 60 sec. averages of the base data. These products will include plots of selected parameters and a compilation of mission log notes as available. Quick-look data will be distributed within 24 hrs. following a flight mission.

5.3.2 Base Measurements Distribution

Base measurement data will be distributed 90 days after the mission is completed in accordance with the Data Products and Publication Schedule of Section 7.0. The data product will consist

TABLE 5.3.1-1: AIRCRAFT BASED REAL TIME DATA

DISPLAYED PARAMETERS

TIME	HR:MIN:SEC
ALTITUDE	FEET
LATITUDE	DEG:MIN
LONGITUDE	DEG:MIN
STATIC AIR TEMP	°C
DEW POINT TEMP.	°C
GROUND TRACK	DEG
TRUE AIR SPEED	KNOTS
WIND SPEED	KNOTS
WIND DIR	DEG.
STATIC PRESSURE	MILLIBARS
OZONE	PPB
POTENTIAL TEMP. (Θ_E)	°C

Publication Schedule of Section 7.0. The data product will consist of IBM-PC compatible diskettes of 10 sec averages of selected aircraft met/nav data. An in-depth meteorological analysis, including special-case trajectories and other requested products, will also be available on request.

5.3.3 Data Analysis/Science Planning Workshop

A data analysis and science planning workshop is scheduled six months after the conclusion of the expedition. The experimenters will describe the performance of their sensors, a sample of the final reduced data, an estimate of the sensor accuracy and precision, and report on key measurement results. The Science Team will review each of the analyses obtained to date, identify those areas requiring additional investigations, and determine the specific details of each investigation that is to be pursued. The Science Team will establish a plan to integrate the individual measurements into a comprehensive dataset and where appropriate will compare the measurements with preliminary theory or model predictions.

5.3.4 Archived Products

All investigator data products submitted in compliance with the data protocol will be placed in the GTE/ABLE-3B expedition archive. Data shall be submitted to the archive in a format described in Appendix E, and be accompanied by a written description of the data set. Data products submitted as tapes, diskettes, or hardcopy should be mailed to:

J.W. Drewry, GTE Data Manager
MS 483
NASA Langley Research Center
Hampton, Virginia 23665-5225

The archive shall be released to the public 21 months after the expedition.

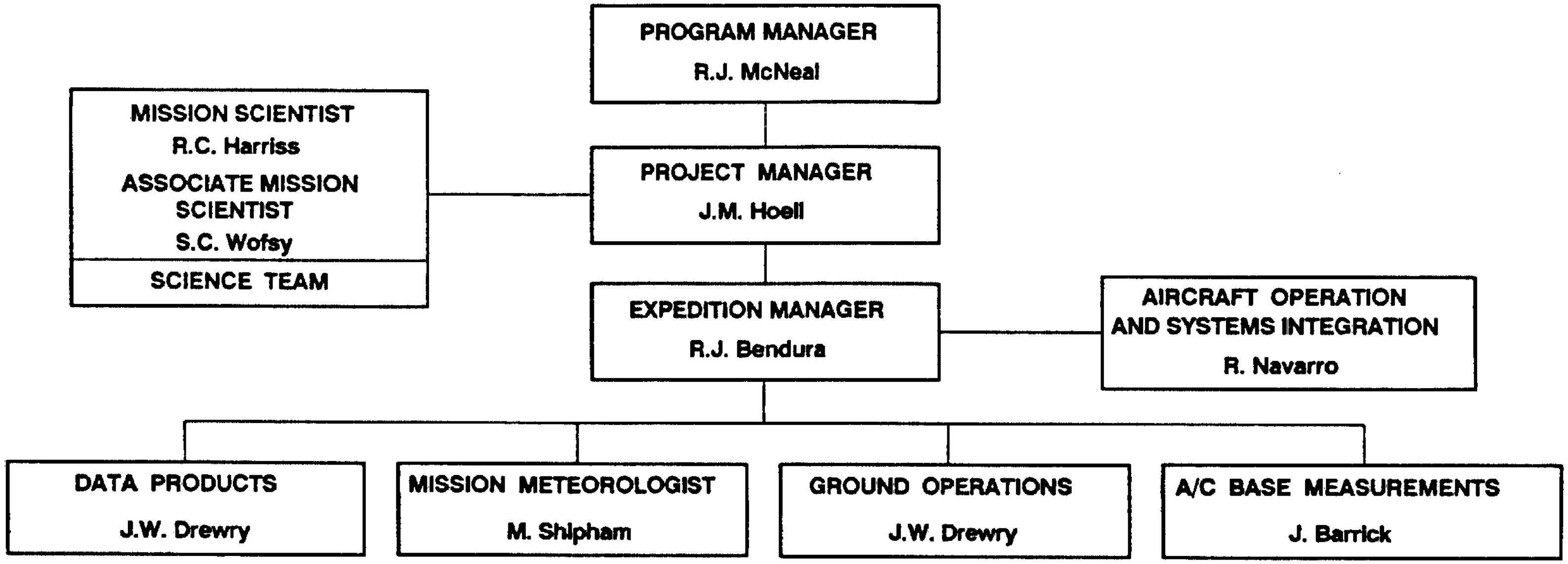
6.0 OPERATIONS

6.1 Functional Organization

The functional organization for implementing the GTE/ABLE-3B expedition is shown in figure 6.1.-1. Names, addresses, and telephone numbers of the project personnel along with the science team members are provided in Appendix F. Also included in figure 6.1-1 and Appendix F are the primary contacts for programs collaborating with GTE/ABLE-3B. A brief description of the ABLE-3B team responsibilities follows:

Program Manager - Responsible for overall program guidance, review and selection of projects and project elements, and funding.

Project Manager - Responsible for the overall management,



CONTACTS FOR COLLABORATING PROGRAMS

CANADIAN NORTHERN WETLANDS PROJECT (CNWP)	
W. Glooschenko	Project Manager
L. Barrie	Project Scientist
W. Harley	Mission Coordinator
I. MacPherson	Aircraft Coordinator
B. Misanchuk	Meteorologist
H. Schiff	Mission Scientist
NASA BIOSPHERIC RESEARCH OF EMISSIONS FROM WETLANDS (BREW)	
G. Whiting	Project Manager
McGILL STATION - SCHEFFERVILLE	
T. Moore	Scientific Director

Figure 6.1-1. Functional organization for ABLE-3B

Mission Scientist - Responsible for all scientific aspects of the ABLE-3B expedition, including being the chief spokesperson for the project, establishing detailed flight and ground measurement objectives and requirements with the Expedition Manager, and Investigators. The Mission Scientist, with the advice of the Science Team and assistance of the Aircraft Manager, is responsible for preparation of each mission flight plan.

Associate Mission Scientist - Responsible for assisting the Mission Scientist in coordinating the planning and field implementation of the science objectives.

Science Team - Responsible for the instrumentation, data gathering, reduction, and analysis, and technical publication of results. As Principal Investigators, contribute to the planning process to assure the best operational use of the instrumentation for the science objectives.

Expedition Manager - Responsible for coordinating and implementing the field operations, preparation of mission plans, determining special support requirements, conducting planning and debriefing sessions, determining operational procedures, and resolving conflicting PI requirements during field operations.

Aircraft Operations and Systems Integration - Works as Aircraft Manager with the Mission Scientist and aircraft crew to prepare flight profiles to meet expedition science objectives considering aircraft capabilities and safety. Responsible for project communications while in flight including in-flight coordination of all requests for changes in flight plans, as well as all activities involving the aircraft on the ground. Responsible for layout, integration, and unloading of aircraft experiments, including the resolution of problems related to weight, power, space, and checkout of instrument operations.

Ground Operations - The individual responsible for ground operations will coordinate the logistics and shipping of all experiment and supporting equipment used in ground-based measurements.

Mission Meteorologist - Responsible for meteorological forecasting and planning for all aircraft flights and for the post-expedition assembly of all meteorological information used in data reduction, analysis, and reporting.

Data Products - The individual responsible for data products will assemble, archive, and distribute PI submitted data.

Aircraft Base Measurements - The individual responsible for Aircraft Base Measurements will operate the instrumentation aboard the aircraft to provide the base measurements (see Table 3.1-2) furnished by the project to all Principal Investigators and the subsequent reduction and compilation of these data for the subsequent reduction and compilation of these data for distribution.

6.2 Operation Sites

Sensor systems integration with the NASA Electra and subsequent checkout and flight testing will be done at the NASA Wallops Flight Facility (WFF) located on Virginia's eastern shore in accordance with the schedules included in Section 7.0 . Laboratory space including 110V and 220V 60Hz power, water, standard mechanical tools and electrical equipment are available at WFF. Requirements for these as well as special support items (e.g., LN_2, dry ice) should be addressed to the Aircraft Operations Manager whose address and phone number are included in Appendix F.

NASA aircraft operations will be conducted primarily out of North Bay and Goose Bay. Laboratory and equipment storage space will be available as close as possible to the Electra parking area. The laboratory space will be heated, equipped with work benches, have 110V/60Hz power, and running water nearby. All tools required to maintain the respective experiments must be provided by the responsible investigators. LN_2, dry ice, a refrigerator, limited 220V/60Hz power, and other special support requirements will be provided per requests submitted to the Expedition Manager at the November 1989 Science Team meeting.

Ground measurement operations will be conducted at a site near Schefferville. See Section 4.2.2 for information on site layout and available support. Address questions and additional support requests to the ABLE-3B Ground Operations Manager (Appendix F).

Meteorological operations will be conducted at the operation bases for the Electra aircraft.

6.3 Shipping - Electra Operations

In general, cost should be the primary factor in determining shipping method which usually dictates surface rather than air transportation. Total shipping weights/costs are limited to the amounts listed in the investigator's proposal unless an exception is granted by the GTE Project Manager. Non-excepted excess costs may be charged to the investigator. All items will be weighed. To lessen shipping weights, supplies may be purchased near the Wallops Flight Facility and North Bay (see 6.5 Supplies and Expendables)

6.3.1 Wallops Flight Facility Operations

Principal investigators are responsible for shipping all equipment and supplies necessary to support their operations at Wallops Flight Facility to the following address:

GSFC/Wallops Flight Facility
Wallops Island, Virginia 23337
Attn: Roger Navarro

Shipments to Wallops Flight Facility are to be charged to NASA by marking shipping documents "Convert to GBL at Destination"

6.3.2 Canada Operations

Bulk shipment of equipment to and supplies by truck from Wallops Flight Facility to North Bay and Goose Bay and subsequently back to the P.I.'s laboratory (by truck and/or air) is the responsibility of the Project Office. However, packing, weighing, and labeling are the responsibilities of the investigator team, including proper labeling and identification of hazardous material. Advance shipments: In some cases it may cheaper and/or necessary to ship equipment not needed at Wallops Flight Facility directly to Canada. Contact the Expedition Manager or Helen Thompson, the STX Project Coordinator for shipping instructions. These items should be shipped to:

Central Material Traffic Terminal
Canadian Forces Base, North Bay
Hornel Heights, Ontario Canada POH 1POC
Attn: Captain Spencer (472-9292)
(NASA Equipment)

6.4 Shipping - Schefferville Ground Operations

Instructions concerning the shipping of supplies and equipment for the ground measurements at Schefferville must be arranged and coordinated through the Ground Operations Manager. As soon as the individual Principal Investigators have determined their requirements, they should contact Mr. J.W. Drewry by mail, telephone, or fax (see Appendix F).

6.5 Supplies and Expendables

Only commonly used expendables such LN_2 and dry ice will be provided by the Project Office. LN_2 dewars must be provided by the Principal Investigators. Specialized gases and supplies unique to only one or a few instruments are the responsibility of the investigator teams. A potential source near WFF is:

Air Products, Inc.
112 Moss Hill Lane
Salisbury, MD 21801
Phone: 301-742-3800

A potential source in North Bay is:

Canadian Oxygen Limited (CANNOX)
1810 Seymour Street
Box 537
North Bay, Ontario
Canada P1B 8J1
Phone: 705-472-6430

6.6.1 Travel - Non NASA Participants

The project office, through STX, will support air and ground transportation requirements for non-NASA participants, in accordance with the NASA travel regulations. Each team is expected to plan travel to take advantage of reduced price air fares and to minimize turn over of personnel and multiple trips. In general, support will be provided for only one round trip air ticket per position, except where return to home base can be accomplished at no additional cost (e.g., per diem cost greater than air fare, etc.) or there is an emergency. Ground transportation at the Electra and ground sites will be provided with the guide lines of one vehicle per team.

6.6.2 Travel - NASA Participants

NASA participants are expected to make travel arrangements according to the procedures of their organization. This includes arrangements for on-site rental vehicles.

6.6.3 Lodging, Per Diem - WFF

All participants are responsible for their own lodging arrangements. Participants should also make reservations for the time expected to be at Wallops following the return from Canada and the unloading of experiment equipment. Participants will be responsible for dealing directly with the hotel for any changes to arrangements that may be required. Participants will be responsible for any extra expenses due to failure to notify the hotel of late arrival, or for not arriving when planned. A list of hotels in Chincoteague along with their telephone numbers follows:

Waterside Motor Inn - 804-336-3434

Refuge Motel - 804-336-5511

Driftwood Motel - 804-336-6557

Island Motor Inn - 804-336-3141

Mariner Motel - 804-336-6565

Travelers will be reimbursed up to the maximum allotted NASA regulations based on receipts (itemized bills) submitted. The current maximum amount is $54.00 for Wallops. This rate is not expected to decrease. If a room is shared then the lodging rate will not exceed each persons cost of the shared room up to the maximum. Receipts are not required for the fixed per diem subsistence (meals and miscellaneous) amount of $26.00. Reimbursement for the fixed per diem subsistence amount will be prorated for partial travel days according to the government travel regulations.

6.6.4 Lodging, Per Diem - North Bay, Canada

6.6.4 Lodging, Per Diem - North Bay, Canada

Lodging arrangements, based on P.I. inputs, have been made in North Bay. Expedition participants do not need to personally make this contact. The lodging accommodations for the period July 2 through July 26, 1990 are at:

Pinewood Park Inn and Country Club
Pinewood Park Drive, Highway #11S
North Bay, Ontario P1B 8J8
Phone: 705-472-0810 FAX: 705-472-4427
Contact: Susan Wright
Rate: $49.15 U.S. single or double

Official government travel rate for North Bay is anticipated to be around $86.00, which covers hotel lodging and meals. For partial travel days this fixed per diem will be prorated according to government travel regulations. Receipts for hotels are required for persons supported by STX.

6.6.5 Lodging, Per Diem - Goose Bay, Canada

Lodging arrangements, base on P.I. inputs, have been made in Goose Bay. Expedition participants do not need to make this contact. Accommodations for the period July 26 to August 10, 1990 are at:

Aurora Hotel
382 Hamilton River Road
Happy Valley, Newfoundland
Phone: 709-896-3398 FAX: 709-896-9608
Rates: single: $61.88;double: $74.55

The official government travel rate for Goose Bay is anticipated to be around $69.00, which covers hotel lodging and meals. Doubling in rooms will be required to stay within per diem. For partial travel days this fixed per diem rate will be prorated according to government travel regulations. Receipts for hotels are required for persons supported by STX.

6.6.6 Lodging, Per Diem - Schefferville Ground Site

Personnel participating in the Schefferville research activities are responsible for making their own lodging arrangements through Doug Barr (address follows) per directions in the 2 February, 1990 memorandum to P.I.'s from Expedition Manager.

Douglas R. Barr
Centre for Northern Studies and Research
McGill University
Burnside Hall
805 Sherbrooke Street W.
Montreal, Quebec
Canada H3A 2K6
Phone 514-398-6051 FAX: 514-398-7437

McGill Subarctic Research Station can provide a limited number of dormitory style accommodations. Official government travel rate for Schefferville is anticipated to be around $69.00, which covers hotel lodging, meals, and all other personal expenses. For partial travel days this fixed per diem rate will be prorated according to government travel regulations. Receipts for hotels are required for persons supported by STX.

6.7 Field Activities

An operations center will be established and manned at each operations site for both aircraft and ground operations. A member of the project team, will head the operations center and be the central point of contact and coordination with the operations personnel and P.I.s.

To ensure proper exchange of information on schedules, meetings, and instrumentation status, each PI is responsible for designating a spokesperson for his experiment. This person will attend scheduled meetings, provide status on his experiment, participate in mission planning, and will be responsible for informing his co-workers of schedule changes.

A status/planning meeting will typically be scheduled on non-flying days. Prime and alternate flight plans are to be developed based on scientific need, forecast weather conditions, and instrumentation status. The Mission Scientist, Aircraft Operations Manager, Mission Meteorologist, a representative for each experiment, Chief Pilot, and Navigator are expected to attend.

A pre-flight status meeting will be held before each flight to review the latest weather information, review the flight plan, instrument status, and make a go\no-go decision with respect to the prime and alternate flight plan. The Aircraft Operations Manager, Experiment Representatives, Mission Meteorologist, and Mission Scientist are expected to participate.

After each flight a debriefing will be held to review all aspects of the mission from weather conditions to instrument performance. The Aircraft Operations Manager, Mission Scientist, Experiment Representatives, Mission Meteorologist, and Chief Pilot are expected to attend.

The type, number and scheduling of meetings for ground site operations at Schefferville will be determined by the Ground Operations Manager in collaboration with ground site P.I.'s.

6.8 Aircraft Access

On non-flight days the aircraft will normally be open and power available from 0800 to 1700. On flight days the aircraft will be accessible 3 hours before take-off and will be secured one hour after landing. Access to aircraft outside of these times must be coordinated through the Aircraft Operations Manager and requests should be made at least 4 hours in advance.

Only designated aircraft crew members will open the aircraft and operate the power distribution panel controls. Experimental apparatus under power will not be left unattended. Under no circumstances will aircraft be left open and unattended.

6.9 Flight Personnel

The maximum number of persons on the aircraft during any flight is 28. All personnel flying on the Electra must have government or invitational travel orders. Each principal investigator should provide the Expedition Manager and Aircraft Operations Manager a list of personnel that will be required on the Electra. In general the following persons or their alternates will be on the aircraft:

Pilot

Co-Pilot

Flight Engineer

Avionics Technician

Mechanic

Aircraft Operations Manager

Mission Scientist

Observers (1 to 2 persons)

PIs and team members

6.10 In-Flight Safety Procedures and Operations Requirements for ABLE -3B Expedition

No smoking while on-board the aircraft.

No alcoholic beverages on-board the aircraft.

Each person must be in his/her assigned seat during each take-off and landing.

The passage through the aircraft must be clear at all times.

All carry-on gear must be secured before take-offs and landings.

Only designated aircraft crew members will operate the power distribution panel controls.

In the event of a power outage, all instrumentation power switches must be set to "off" position before power distribution panel is reset. Experiments will be brought on-line in sequence, if necessary, to avoid transient overloads.

One person with each experiment must monitor the intercom at all times and remain with his experiment.

The Aircraft Manager is the interface between the flight crew and the experimenters.

6.11 Nominal Activities for Non-Flight Day

The following is a nominal list of activities that are anticipated on non-flight days

Weather briefing

Aircraft open and power available to experimenters

Planning session for next mission

- Review instrument status
- Weather criteria
- Develop prime and alternate flight plans
- Identify present or potential problem areas

Work aircraft clearances; tentative evening work schedule

Weather update; evening work schedule

6.12 Nominal Schedule for Flight Day

H - 3	Aircraft open and power available to experimenters
H - 2-1/2	Weather briefing
H - 2	Review flight plan, determine experiment status, go/no-go decision
H - 1-1/2	File flight plan
H - 1/2	Weather update
H	All technical crew on-board; doors close
H + 1/2	Take off

H + 6	Land, aircraft secured for refueling
H + 7	Secure aircraft unless prior arrangements have been made for access and power
H + 8	Mission debriefing

6.13 <u>Flight Criteria</u>

The go/no-go and mission abort decisions for a particular mission will be made by the aircraft commander based upon safety considerations. The impact on the status of experiment instrumentation will be assessed based upon the objectives of the particular flight.

6.14 <u>Medical Considerations</u>

No specific inoculations are required for entry into Canada or Greenland, and none are required for reentry into the U.S. Persons with potentially serious medical problems are requested to inform the Expedition Manager and work out contingency plans for medical attention if the need should arise.

Each investigator should be aware that NASA does not provide any life or health insurance for personnel involved in flight experiments. Each individual should determine if and how their present coverage and, in particular how their life insurance, could be impacted when flying on an aircraft such as the Electra.

7.0 SCHEDULES

7.1 <u>ABLE-3B Major Milestones</u>

Activity	Date, 1990
Ground Operations - Schefferville	
Shipping Deadline	April 13
Begin Setup	May 14
Sites Operational	June 10
Intensive Data Period	July 23 - Aug. 10
Begin Takedown	Aug. 21
Depart	Aug. 24
Electra Operations	
Sensor Systems Integration	June 4 - June 22
Systems All-Up Tests	June 22 - June 28
Deploy to North Bay	July 2
Data Missions - North Bay	July 5 - July 24
Deploy to Goose Bay	July 26
Data Missions - Goose Bay	July 29 - Aug. 8
Depart for Wallops	Aug. 11

Data Management

Archive Submittal	Feb., 1991
Data Workshop	Feb., 1991
Spring AGU/Science Team Mtg.	May, 1991
Submittal to GRL	July, 1991
Submittal for Special Issue	Feb., 1992
Archive Release	May, 1992

7.2 ABLE-3B Operations Schedule

See Figure 7.2.

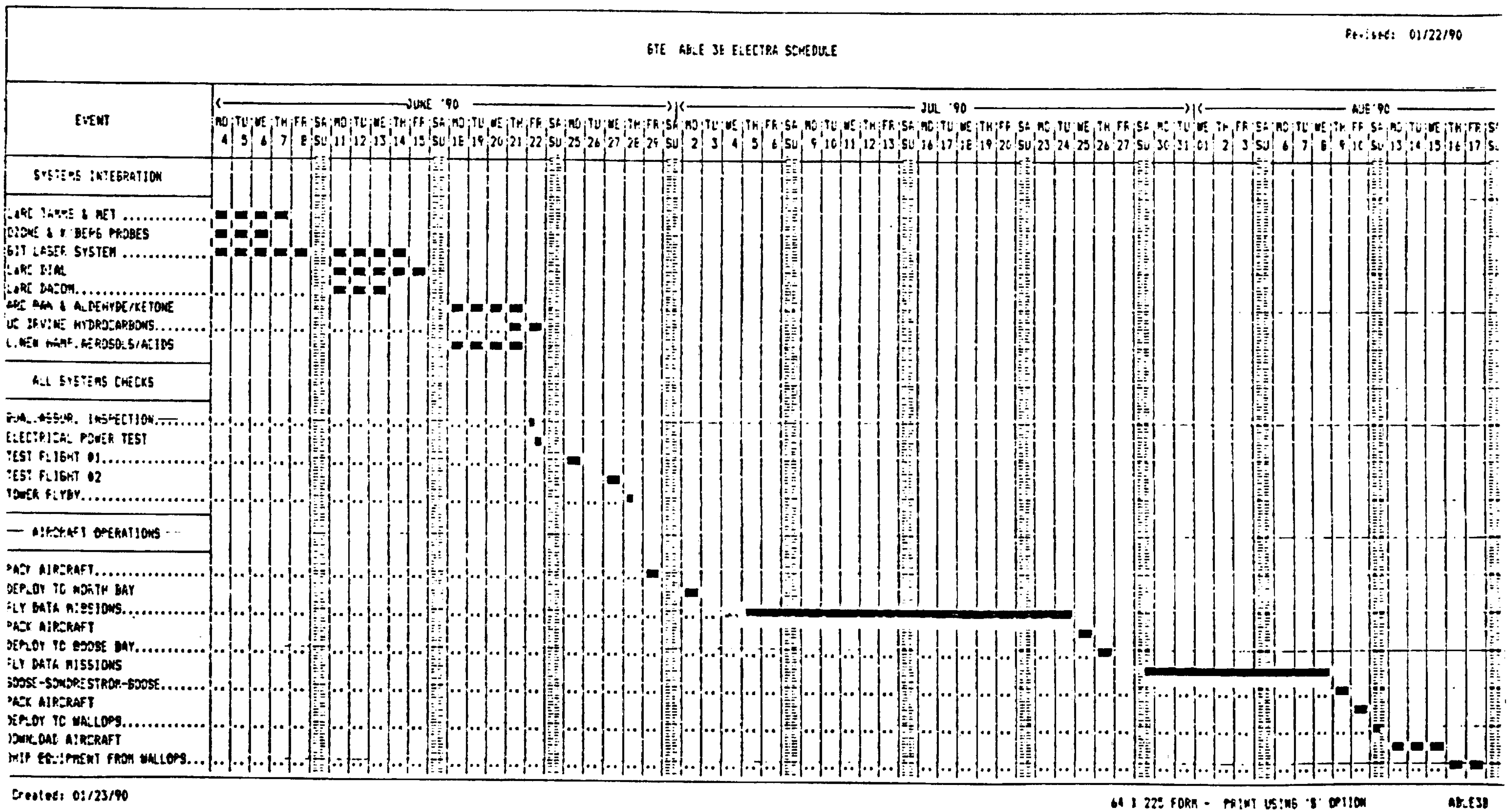


Figure 7.2. ABLE-3B Operations Schedule

APPENDIX A

Aircraft Characteristics and Instrument Layout

Electra/NASA 429

The GSFC/WFF Lockheed Electra is a low wing, medium altitude, moderate range aircraft powered by four Allison turboprop engines. The layout of experiment and general space allocation for ABLE-3B is shown in Figure A-1. The flight crew will consist of six people: pilot, co-pilot, flight mechanic, avionics technician, safety observer, and mission manager. A maximum of 22 seats will be available for operation of science instruments. All personnel flying on the Electra will have government or invitational travel orders and will be assigned a duty during the flight which is pertinent to the objectives of ABLE-3B.

The aircraft performance characteristics for ABLE-3B are:

True airspeed:	180-315 knots
Max. gross weight:	116,000 lbs
Payload capacity:	22,000 lbs
Max. fuel loading:	34,000 lbs
Flight endurance:	5.5 hours at 300 knots
Max. operating altitude:	21,000 feet
Cruising altitude:	15,000 - 21,000 feet
Experimenter electrical power:	35.5kw, 60Hz, 115v single phase
	15kw, 400Hz, 115v three phase
	2.2kw, 28 VDC

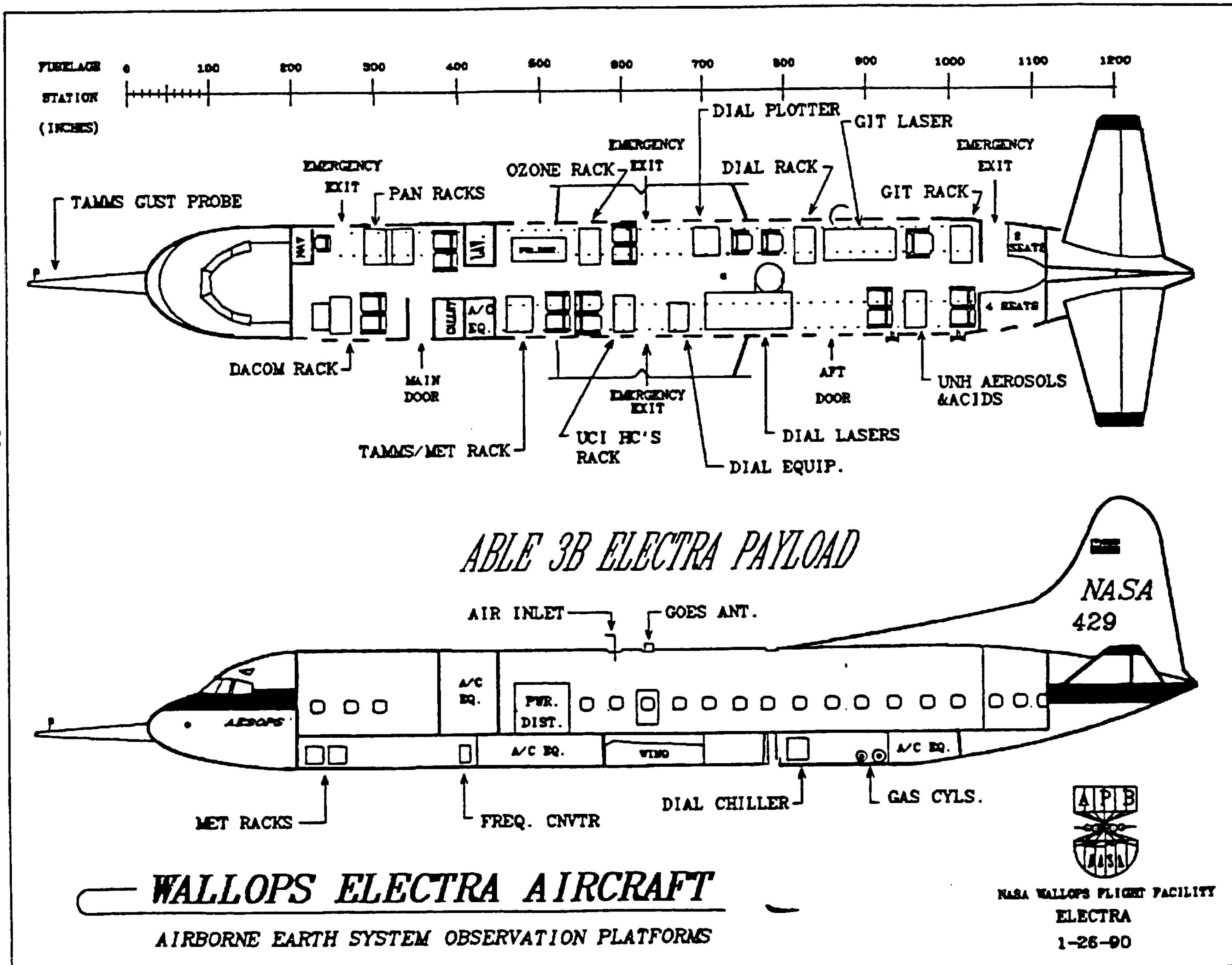

FUSELAGE STATION (INCHES)
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
TAMMS GUST PROBE
EMERGENCY EXIT
PAN RACKS
OZONE RACK
EMERGENCY EXIT
DIAL PLOTTER
DIAL RACK
GIT LASER
GIT RACK
EMERGENCY EXIT
2 SEATS
4 SEATS
DACOM RACK
MAIN DOOR
TAMMS/MET RACK
EMERGENCY EXIT
UCI HC'S RACK
DIAL EQUIP.
DIAL LASERS
AFT DOOR
UNH AEROSOLS &ACIDS
ABLE 3B ELECTRA PAYLOAD
AIR INLET
GOES ANT.
NASA
429
A/C EQ.
PWR. DIST.
A/C EQ.
A/C EQ.
MET RACKS
FREQ. CNVTR
DIAL CHILLER
GAS CYLS.
WALLOPS ELECTRA AIRCRAFT
AIRBORNE EARTH SYSTEM OBSERVATION PLATFORMS
NASA WALLOPS FLIGHT FACILITY
ELECTRA
1-26-90

Figure A-1.

APPENDIX B

ABLE-3B EXPERIMENT DESCRIPTIONS

Instrument: OZONE AND AEROSOL DIAL SYSTEM

Principal Investigator: Edward V. Browell

Organization: NASA Langley Research Center (804) 864-1273
Mail Stop 401A FTS 928-1273
Hampton, VA 23665-5225

Principle of Operation:

The airborne differential absorption lidar (DIAL) system consists of four lasers that transmit nearly simultaneously four laser wavelengths (286, 300, 600, and 1064 nm) through the zenith- and nadir-mounted quartz windows in the Electra. The DIAL technique for the measurement of O3 profiles uses the 286 and 300 nm laser outputs. The laser wavelengths at 600 and 1064 nm are used to profile the distribution of aerosols and clouds at the same time as the O3 profile is being measured. Backscatter returns from the atmosphere at the four laser wavelengths are collected by zenith- and nadir-viewing telescopes, directed onto separate detectors, digitized, recorded, and analyzed in real time. Simultaneous color plots of aerosol/cloud distributions and O3 distributions are produced on the Electra for real-time experiment sampling decisions. The system is operated at a 5-Hz rate with the averaged lidar data stored at 1/3-Hz (15-m vertical resolution; 300-m horizontal resolution). The vertical and horizontal resolutions for the aerosol/cloud analysis are 15 m and 300 m, respectively, to a range of 8 km above and below the aircraft, which typically flies at an altitude of 4 km. The O3 concentrtion profiles have a vertical and horizontal resolution of 210 m and 7 km, respectively, to a range of 6 km above and below the aircraft.

Accuracy: <10% for O3 concentrations; <5% for aerosol backscatter returns.

Resolution:

	Aerosols	Ozone
Vertical	15 m	210 m
Horizontal	300 m	7 km

References:

1. E. V. Browell et al., "NASA Multipurpose Airborne DIAL System and Measurements of Ozone and Aerosol Profiles," Appl. Opt. 22, 522-534 (1983).

2. E. V. Browell, "Differential Absorption Lidar Sensing of Ozone," Proc. IEEE 77, 419-432 (1989).

Hydrocarbon and Halocarbon Analysis

University of California, Irvine

A 2-stage metal bellows pump pressurizes stainless steel canisters to 75 psig onboard the NASA Electra Aircraft. Samples require between 30-60 seconds to fill depending upon altitude, and as many as 48 samples can be collected on each flight. The canisters are then returned to our temporary laboratory, in North Bay, Canada, for sample analysis. Methane, ethane, ethene, ethyne,, propane, propene, butane, pentane, isoprene, hexane, benzene and toluene are the hydrocarbons routinely analyzed. To this we expect to add the analysis of selected terpenes including a-pinene and b-pinene. Methychloroform, carbon tetrachloride, perchloroethene, CFC-12, CFC-11, and CFC-113 are the halocarbons normally analyzed and we are configured to separate and detect various bromine compounds, but at this time we are still conducting tests to determine whether our canisters will maintain these gases. The compounds mentioned are analyzed on a Hewlett-Packard 5890a gas chromatograph equipped with a flame ionization detector (FID) for the hydrocarbons and an electron capture detector (ECD) for halocarbon analysis. A purge and trap method is employed with about 90% of the trapped 3 liters being directed to the FID and the remainder going to the ECD. A dry air standard collected at Niwot Ridge, Colorado is assayed after a set of 8 canisters is measured. Approximately 1000 samples were collected and assayed during the ABLE-3A mission and we expect to increase that to 1200-1500 for the ABLE-3B. The additional samples will be collected at the ground site at Shefferville in order to determine whether the nonmethane hydrocarbons, terpenes in this case, are present at concentrations that could influence the continuous methane monitoring system which detects total hydrocarbons.

R. W. Talbot: Acidic Gases and Aerosol Chemistry for ABLE 3B

Measurements of nitric acid, and the organic acids formic and acetic, will be performed aboard the Electra aircraft. These species should be the principal acidic gases in the atmosphere over the Canadian tundra and boreal environments studied in ABLE 3B. In addition, samples will be collected to determine the water-soluble composition of atmospheric aerosols (NO_3^-, SO_4^{2-}, Cl^-, $C_2O_4^{2-}$, $CH_3SO_3^-$, Na^+, NH_4^+, K^+). In the boundary layer over the study area nitric acid and particulate NO_3^- should comprise a significant fraction of the total reactive nitrogen (NO_y). Information will also be obtained on the biogenic sulfur cycle over the Canadian ecosystems through measurements of methyl sulfonate and non-sea-salt SO_4^{2-} in atmospheric aerosols.

In addition to the large-scale distributions obtained from aircraft sampling, atmospheric aerosols will be sampled at the Fraserdale ground-based site. Sampling will be conducted daily from May–August to obtain a continuous temporal record during most of the growing season. This intensive study is a joint colloboration with Dr. Len Barrie at Atmospheric Environment Service in Canada.

ABLE-3B IN SITU OZONE AND AEROSOL NUMBER DENSITY MEASUREMENTS

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The in situ ozone and aerosol package is similar to that used during earlier ABLE experiments [Ref. 1-3]. Ozone is measured by two different techniques: C_2H_4 chemiluminescence and NO chemiluminescence. The C_2H_4 chemiluminescence instrument has a response time of about 2 seconds to 90% of reading and has been modified such that sensitivity is independent of altitude [Ref. 4, 5]. The NO chemiluminescence instrument has a 10-Hz response and has been designed specifically for the ABLE eddy correlation flux studies [Ref. 6, 7]. Instrument accuracy (both) are of the order of 5 parts per billion by volume (ppbv), or 5%, as determined by NO gas phase titration calibration traceable to the National Institute for Standards and Technology (formerly the National Bureau of Standards). During integration of the instruments onboard the Electra, the calibration of the instruments are verified via independent calibration against a 3-m path UV photometer. Both instruments have a precision of about 2 ppbv or 2% for a 10-second average.

Two aerosol probes continuously monitor aerosol number density (aerosols per cubic centimeter of air sampled) as a function of time and size diameter. A forward scattering spectrometer probe (FSSP) counts and sizes aerosols in the size range of 0.5- to 8-um diameter. An active scattering aerosol spectrometer probe (ASASP) counts and sizes aerosols in the size range of 0.12- to 3.12-um diameter. The FSSP sampling volume is located external to the aircraft in free-stream flow, and aerosols are sized into fifteen 0.5-um-wide bins as they pass through an He-Ne laser beam. The ASASP sample volume is located internal to the probe housing which is mounted in free stream. The ASASP also uses a 15-bin classification system, but with progressively increasing-width bins. The sizing range for the different bins are given below for both instruments. Both instruments are sensitive to liquid and solid aerosols as each samples unheated ambient air. Count periods for both instruments are 1 second. However, for most applications the data are averaged over 1- to 5-minute periods. Some data are presented as 10-second averages to correspond to appropriately averaged ozone data (particularly altitude profiles). For reference purposes, the ASASP is referred to as the small probe (small aerosol) and the FSSP as the large probe (large aerosol).

Data are recorded onboard the aircraft using a Compaq 286 PC system. Onboard display of the data include tabulated print out of 1-minute averages (ozone related data only) and real-time graphical display of 10-second ozone as a function of time. The graphical display is "wiped clean" and restarted on a 30 to 60-minute cycle with the earlier plots stored for post mission replay (hardcopy). The aerosol data are processed post flight. Considerable effort is placed on post-mission analyses and generating data products within 12 to 24 hours after completion of a mission. Normal operations include complete processing of the ozone and aerosol data (e.g., altitude profiles and time plots of ozone, aerosol number density, and size distributions) and presentation during briefings, flight planning, etc. In general and on a "time available" status, special data requests for the project and science team can be satisfied.

Aerosol Size Bins

Channel #	FSSP (Large Probe)	ASASP (Small Probe)
1	0.5 to 1.0 um	0.12 to 0.145 um
2	1.0 to 1.5	0.145 to 0.195
3	1.5 to 2.0	0.195 to 0.27
4	2.0 to 2.5	0.27 to 0.37
5	2.5 to 3.0	0.37 to 0.495
6	3.0 to 3.5	0.495 to 0.645
7	3.5 to 4.0	0.645 to 0.82
8	4.0 to 4.5	0.82 to 1.02
9	4.5 to 5.0	1.02 to 1.245
10	5.0 to 5.5	1.245 to 1.495
11	5.5 to 6.0	1.495 to 1.77
12	6.0 to 6.5	1.77 to 2.07
13	6.5 to 7.0	2.07 to 2.395
14	7.0 to 7.5	2.395 to 2.745
15	7.5 to 8.0	2.745 to 3.12

Cited References

1. Gregory, G. L., R. C. Harriss, R. W. Talbot, R. A. Rasmussen, M. A. Garstang, M. O. Andrea, R. R. Hinton, E. V. Browell, S. M. Beck, D. I. Sebacher, M. A. K. Khalil, R. J. Ferek, and S. V. Harriss, Air chemistry over the tropical forest of Guyana, J. Geophys. Res., 91, 8603-8612, 1986.
2. Gregory, G. L., E. V. Browell, and L. S. Warren, Boundary layer ozone: An airborne survey above the Amazon Basin, J. Geophys., 93, 1452-1468, 1988.
3. Gregory, G. L., E. V. Browell, L. S. Warren, C. H. Hudgins, Amazon basin ozone and aerosol: Wet-season observations, accepted J. Geophys. Res., Feb. 1990.
4. Gregory, G. L., C. H. Hudgins, and R. A. Edahl, Jr., Laboratory evaluation of an airborne ozone instrument which compensates for altitude/sensitivity effects, Envir. Sci. & Tech., 17, 100-103, 1983
5. Gregory, G. L., C. H. Hudgins, and R. A. Edahl, Response to comment on laboratory evaluation of an airborne ozone instrument which compensates for altitude/sensitivity effects, Envirn. Sci. & Tech., 17, 560-564, 1983
6. Gregory, G. L., C. H. Hudgins, J. Ritter, and M. Lawrence, In situ ozone instrumentation for 10-Hz measurements: Development and evaluation, Proceedings of Sixth Symposium on Meteorological Observations and Instrumentation, New Orleans, LA, Jan. 12-16, 1987, pp 136-139.
7. Ritter, J. A., D. H. Lenschow, J. D. Barrick, G. L. Gregory, G. W. Sachse, G. F. Hill, and M. A. Woerner, Airborne flux measurements and budget estimates of trace species over the Amazon basin during the GTE/ABLE-2B Expedition, Submitted J. Geophys. Res., August 1989.

Ga Tech LIF $NO/NO_2/NO_y$ Instrument

John Bradshaw and S. Sandholm

The Ga Tech Laser Induced Fluorescence (LIF) based sensor is capable of simultaneous detection of NO, NO_x (NO_2 + NO) and total reactive odd-nitrogen NO_y. The NO detection methodology employed is based on the spectroscopically selective step-wise laser excitation of specific ro-vibronic transitions in the $X^2\Pi \Rightarrow A^2\Sigma^+$ system near 226 nm and the $A^2\Sigma^+ \Rightarrow D^2\Sigma^+$ system near 1.1μ. The Two-Photon Laser Induced Fluorescence (TP-LIF) resulting from this excitation process takes place from $D^2\Sigma^+ \Rightarrow X^2\Pi$ transitions which are monitored near 190 nm.

NO_2 is measured by using the photolytic conversion process $NO_2 + h\nu \Rightarrow NO + O$ with subsequent detection of the photolytically generated NO via the TP-LIF technique. The photolytic convertor uses a high pressure xenon arc lamp (1000 W) with dichroic filters to limit the photolysis band width to $350 < \lambda < 410$ nm. The convertor design can produce 60% conversion efficiency with sample residence times of < 7 sec, without allowing the photolysis light to interact with the cell walls.

NO_y is measured by using a gold catalytic convertor with CO as an added reducing agent. The conversion process $NO_y + CO \xrightarrow[AU]{300\text{-}350^\circ C} NO$ is followed by detection of catalytically formed NO using TP-LIF.

In this instrument the 226 nm and 1.1μ laser beams are co-linearly combined and passed through three separate sample cells dedicated to: 1) ambient NO detection, 2) ambient NO_2 detection, and 3) ambient NO_y detection. In addition, to simultaneously monitoring the signals from the NO, NO_2, and NO_y cells, referencing cells containing a known amount of NO are monitored as an internal standard.

The ambient sampling manifold is constructed of porcelain glass coated tubing that is thermally insulated and operated at high flow rates providing short sample residence times (< 1 sec). In addition, the photolytic convertor cell is actively maintained near ambient temperatures.

Calibration of the system is accomplished via standard addition of either NO, NO_2, or NO_y standards provided from a serial dilution system using standards supplied in high pressure cylinders.

Data is recorded in typically a one minute format for NO and NO_y and a three minute format for NO_2. Limits of detection (S/N - 2/1) average: 1) for NO; 3pptv (1 min, int.) 2ppt (6 min. int.) and 2) NO_2 4pptv (3 min. int.) 2ppt(6 min int.). Measurement precision (1σ) for [NO] - 15 pptv [NO_2] - 30 pptv and [NO_y] - 500 pptv averages ± 16%, ± 20%, and ± 5 % respectively for 3 min.

egration periods and improves with the square root of the integration time. Absolute accuracy is estimated to be ± 15% NO, ± 18% NO_2, and ± 15% NO_y (at the 95% confidence limit).

Interferences and "offset uncertainties" in the TP-LIF detection of NO have now been shown to be ≤ 2pptv. Interferences in the NO_2 conversion process may include minor thermal decomposition of HO_2NO_2 and photolysis of RNO_x compounds that photolyze in the 350 - 410 nm region. The thermal regulation and short residence time of the photolytic convertor should minimize decomposition of HO_2NO_2. Photolytic interferences from RNO_x are believed to be < .5% $[NO_y]$ based on present test. No known positive interference exists in the total conversion of NO_y compounds and negative interferences caused by convertor efficiency loss are continually checked and easily corrected should they occur through cleaning procedure.

TURBULENT AIR MOTION MEASUREMENT SYSTEM (TAMMS)

The Turbulent Air Motion Measurement System (TAMMS) is an airborne platform that is capable of making measurements of both mean and turbulent quantities of the ambient three-component wind field and the scalar distributions of temperature and humidity. With this platform, a real-time determination of the dispersive capability of the Planetary Boundary Layer can be obtained through its ability to measure the ambient wind field (and its shear with height) as well as the local fluxes of momentum and sensible and latent heat. By combining the measurement capabilities of the TAMMS with data from available fast-response chemical sensors (O_3, CO, CH_4), the turbulent flux, or transport, of these species can be obtained as well.

The TAMMS platform can be considered as an integration of various subsystems: (1) fast-response meteorological sensors; (2) boom/INS; and (3) baseline meteorological sensors. The lateral and vertical atmospheric velocity fields are determined from taking the difference between the velocity of the aircraft with respect to the Earth (referenced to an inertial coordinate system) and the velocity of the air with respect to the aircraft. The latter requires a knowledge of the airflow about the aircraft. On the NASA Electra, these data are obtained from a pitot-static system with temperature compensated paro scientific absolute and differential pressure transducers and a set of orthogonally oriented, rotating balsa vanes (for measuring attack and sideslip angles). These sensors are affixed to a graphite-epoxy nose boom 4m in length. This boom places the sensors at a sufficient distance forward of the fuselage so that they are minimally influenced by the flow around the aircraft.

Aircraft velocity with respect to the Earth is obtained through a high resolution Inertial Navigation System (INS). The horizontal velocity components of the airplane in the inertial reference frame are obtained directly from a binary output bus from the INS. The vertical velocity of the airplane in the inertial reference is obtained from integrating the INS accelerometer outputs.

Air temperature is measured by a Rosemount Model 102 non-deiced total temperature probe mounted on the nose-boom. Fast response water vapor measurements are made by baselining the fast-response Lyman-alpha hygrometer with a slower responding EG&G 137 dew point hygrometer.

As a result of a careful calibration of the system, stemming from tower fly-by and in-flight maneuvers, the TAMMS platform is capable of measuring the source or sink strength of important trace species to or from an underlying surface. By executing a carefully designed flight pattern, the in-situ photochemical production or destruction of a species can also be determined.

Measurements and chemistry of peroxyacetyl nitrates (PANs) and their carbonyl precursors in the troposphere

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It is now generally agreed that PAN, a specific tracer of nonmethane hydrocarbon (NMHC) and NO_x chemistry, is a major component of reactive nitrogen and a reservoir for nitrogen oxides in the global troposphere. Acetaldehyde and acetone are key intermediate products of NMHC oxidation and precursors for PAN formation. In this experiment we seek to measure tropospheric concentrations of PAN and its aldehyde/ketone precursors (PANAK). Capillary and packed gas chromatographic columns and precolums are used to separate key species of interest from the complex air matrix. The instrument uses a parallel detection scheme with nitrogen species and halocarbon tracers being measured by a dual electron capture detector while aldehyde/ketones are measured by a reduction gas detector. 100 to 500 ml of ambient air are drawn through a window probe and cryogenically preconcentrated at a controlled temperature of -150°C to obtain detection sensitivities of about 1 ppt for PAN, PPN, CH_3ONO_2 and C_2Cl_4, and 10 ppt for aldehyde and ketones. All calibrations are performed aboard the aircraft in real time. The experiment is substantially computer controlled and organic nitrogen and carbonyl analysis are performed every 6 minutes and 12 minutes, respectively. Concurrent measurements of organic nitrogen species and their carbonyl precursors are being attempted for the first time in this experiment. Statistical techniques and photochemical models are used to analyze and interpret these data. An important goal is to obtain knowledge on the distribution, sources, and chemistry of select reactive nitrogen and carbonyl species.

Carbon Monoxide and Methane Measurements for ABLE-3B

CO and CH_4 measurements on the Electra aircraft will be provided by a tunable diode laser instrument that is often referred to as DACOM (Differential Absorption CO Measurement). For CITE-1, CITE-3, ABLE-2A, and ABLE-2B expeditions, DACOM provided only CO measurements; however, for the ABLE-3A expedition, DACOM's capabilities were extended to simultaneously measure CH_4 and CO concentrations at a sufficient sampling rate to also permit eddy correlation flux measurements. A similar capability with some refinements is planned for ABLE-3B.

The operating principle of DACOM is briefly explained below. A TDL lasing in the 3.3 μm CH_4 band and one lasing in the 4.7 μm CO band are used to detect these gases using a differential absorption technique. Air from the aircraft free airstream is continuously drawn through a probe and subsequently through an optical chamber where the differential absorption measurements are made. The optical chamber is a 1.5 liter volume White cell that encloses a 10 meter long folded optical path. The White cell is maintained at a reduced pressure of 100 Torr to narrow the gas absorption lines and thereby minimize potential overlap from undesired absorption lines. Through a combination of temperature and injection current tuning, the wavelength of each TDL is fine tuned to an isolated CH_4 or CO line. Rapid modulation of the injection current (≈ 10 kHz) is then used to repetitively sweep the wavelength of each TDL across the respective absorption features. The presence of CO and CH_4 in the White cell amplitude modulates the radiation from each TDL during the wavelength sweep. These absorption signals are detected by InSb detectors located near the exit of the White cell. For ambient levels of CO and CH_4 the magnitudes of the absorption signals are linearly proportional to the CO and CH_4 mixing ratio present in the White cell. Instrument calibration is accomplished by periodically flowing calibration gas with known concentrations of CO and CH_4 through the White cell. These working gas standards will be referenced against master standards at the laboratory of Dr. Paul Steele (NOAA, Boulder, CO).

DACOM will operate in two air sampling modes--a slow response mode optimized for high precision concentration measurements and a fast response mode optimized for eddy flux measurements. In the slow response mode, an air flow of ≈ 3 slm is thermally conditioned by a heat exchanger and H_2O (v) is removed with a dryer. A 1/e time response of ≈ 3 seconds and measurement precisions of 0.2 percent CH_4 and 2 percent CO are expected. This measurement mode will be used during all altitude profiles and during level flight above the boundary layer. Measurements within the boundary layer will be made in the fast response mode to enable calculations of eddy gas fluxes during all low level flights. In this mode the flow rate is increased by a factor of ≈ 100 resulting in a 1/e time response of ≈ 60 msec. At this high flow rate, the air sample is only partially conditioned (i.e., no H_2O(v) is removed and only rapid temperature fluctuations are suppressed). Since the flow is not fully conditioned some weak affects due to temperature and H_2O(v) slightly degrade the precision and accuracy. Techniques to compensate for these affects will be tested during the ABLE-3B expedition.

TURBULENT EXCHANGE MEASUREMENTS IN THE CANADIAN BOREAL FOREST AND NORTHERN WETLANDS: ABLE-3B

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Two micrometeorological towers (e.g., 6m and 30m) will be instrumented to obtain measurements of heat, momentum, and moisture fluxes using the eddy correlation method over two distinct surface types. These surface types will include, a wetland marsh and the boreal forest. Complementary radiative and soil heat flux measurements will be obtained in order to estimate the major components of the heat budget. Vertical velocity fluctuation measurements will be obtained for direct eddy correlation measurements of the fluxes of O_3, CO_2, CH_4, and total hydocarbon, measurements to be made by the group led by S. Wofsy from Harvard. The boundary layer environment will be characterized over an extended period of the arctic growing season to provide a context for measurements to be made by the research aircraft during the planned intensive field observation period. This effort will include designing and carrying out regular launching of sondes with the aim of determining convective boundary layer growth rates and identifying periods for which nocturnal and local wind circulations may be important in interpreting chemical flux measurements.

Eddy correlation flux measurements will be performed at the top of a 6m tower at the marsh site and at two or three levels on a 30m tower at the forest site. Measurements at the small tower will be primarily characteristic of the marsh environment. The taller tower at the boreal forest site will extend approximately three times the forest canopy height. Thus, we have an opportunity to examine not only how the patchy environment manifests itself in terms of turbulent flux divergence in the vertical (another aspect of the "footprint definition) but also describe the "roughness sublayer" just above the canopy. Gradient measurements of the wind speed and wet- and dry-bulb temperatures at four levels on the large tower and two levels on the small tower will be needed both for making flux estimates for trace gases for which no rapid-response sensor is available and for determining the transport terms in turbulent budgets of heat, momentum, and moisture.

Measurements will be obtained of the radiative components of the heat balance: Short wave radiation incoming and reflected S↓ and S↑, long wave radiation being emitted from the air L↓ and from the ground, L↑. The net radiation estimate at each site is to be made both by taking the sum of the components and, independently, using net radiometers at each site. Because of the direct association with photosynthesis, the incoming and reflected photosynthetically active radiation, PAR↑ and PAR↓ will also be measured as a secondary objective.

SURFACE AND NEAR-SURFACE FLUX MEASUREMENTS FOR GTE/ABLE-3B

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Measurements from the surface and micrometeorological towers at the Schefferville ground site will provide continuous profiles of NO, NO_2, NO_y, O_3, CO_2, total hydrocarbons (THC), and CH_4. The high-speed measurements of most of these species with the high-frequency data of D. Fitzjarrald, SUNY, for wind, humidity, and temperature will allow determination of the eddy-correlation fluxes. Two tower sites are planned. A 6m tower will be used to characterize the marsh or bog site while a 30m tower will focus on a larger "footprint" of the boreal forest environment. Data for these ecosystems will provide comparisons for the other high latitude region, the tundra, measured near Bethel, Alaska in ABLE-3A as well as additional contrasts with the Amazon Basin results of ABLE-2A and -2B. As in earlier investigations, studies of the O_3 budget, CO_2 uptake, and the role of pollutant transport will be conducted. The initiation of setup and checkout activities in mid-May, 1990 may provide some data during the thawing cycle prior to the formal operational period of mid-June to mid-August.

NASA - BREW Program
(Biospheric Research of Emissions from Wetlands).

Summary of Scientific Objectives for Canadian Field Mission
Schefferville, Quebec / Moosonee, Ontario 1990

<u>Project Goals:</u> The overall objective of the NASA BREW program is to establish a greater understanding of the biogeochemical cycling in wetlands that have an impact on global processes. This objective has 3 general research strategies: 1) determination of magnitude, transport mechanism, and controlling variables in biogenic gas exchange; 2) establish linkages between inventoried parameters (i.e. vegetation type, climate) and factors controlling gas emission; 3) incorporation of these linkages into a geographic wetland inventory utilizing remote sensing technology to obtain regional to global estimates of exchange.

<u>Research Projects</u>

Mike A. Hardisky (Univ. Scranton, PA), Mike F. Gross (Gettysburg College, PA), Jim A. Doolittle (USDA-SCS), Paul L. Wolf (Lebanon Valley College, PA), Vic Klemas (Univ. Delaware, DE).

The research will entail a broad range of investigations including characterization of the vascular plant communities, both above and below ground, characterization of subsurface stratigraphy and depth to bedrock, profiles of dissolved methane in the soil water, and spectral characteristics of plant canopies.

1. **Plant Communities** - Representative plant communities will be harvested to determine biomass composition of the canopies. Live leaf biomass, stem biomass, dead biomass, canopy height and culm density will be determined for the aboveground macrophytic communities. Distribution of live and dead belowground biomass will be sampled by coring. Some seasonal work will be initiated in June to provide some information on root production and turnover in the major plant communities.

2. **Remote Sensing of the Substrata** - Ground penetrating radar measurements will be used to determine depth to bedrock, distribution of organic materials and degree of humification in these substrates. These radar measurements will be supported by ample ground truth samples.

3. **Methane Profiles** - Interstitial water methane profiles will be determined in the major plant communities sampled. Interstitial soil water samples will be collected using porous teflon sippers at 5 cm intervals to 25 cm. Sampling will occur at the same sites as chamber flux measurements. All areas are to be sampled as described above in (1.).

4) **Spectral Characteristics of Plant Communities** - Spectral reflectance in Spot and Landsat wavebands will be collected for representative plant communities in each sampling site. These data will be used to assist in

biomass estimation and species distribution using remote sensing data. The ground-gathered data will be used to interpret and eventually extrapolate specific habitat flux measurements to a regional scale using Landsat or Spot images of this region. We will also collect ground spectral data on the day of the satellite overpass to allow proper atmospheric corrections.

Chris S. Martens, Bill Ussler, Cheryl Kelley (Univ. N. Carolina),
Jeff P. Chanton, Jim Happell (Florida State Univ.)

The UNC/FSU team will tackle three principle objectives. The first of these is to characterize the carbon and hydrogen isotopic composition of methane emitted to the troposphere from wetlands in the Schefferville area. we also plan to characterize methane stored as dissolved or gas bubbles in the sediments and soils. Emission will be measured using conventional chamber techniques in collaboration with the established Canadian methane flux group (Nigel Roulet and Tim Moore). Biweekly or more frequent isotopic samples will be collected from late May through early September at both NASA-BREW sites and the Canadian Capricorn site. We will be solely responsible for a seasonal series of pore water methane concentration and isotopic measurements necessary for understanding controls on gas composition and emission rates.

Our second objective, closely related to the first, is to study and quantify the impact of dominant macrophytes on the isotopic composition of dissolved methane and methane emissions. We have recently documented plant-enhanced gas transport processes at other BREW sites in Alaska and the Florida Everglades and plan to utilize a combination of gas composition and radon measurements at the Canadians sites. The work will include plant stem gas composition and isotopic measurements plus a series of radiochronometric tracer and plant detritus/sediment decomposition studies.

Our third objective is to quantify gas transport processes at the 30 m GTE/ABLE tower site in collaboration with the Wofsy/Fitzjarrald team. We will be making continuous measurements of atmospheric radon gradients at four heights on the tower using tubing and pump-counter units attached to four independent detectors located in the instrument tent. Direct soil radon flux measurements will be made at representative sites around the tower using two additional detectors.

John Dacey (Woods Hole Oceanographic Institute, MA)

DMS Investigations

I propose to conduct survey work on surface DMS concentrations on James Bay. These measurements will be (if possible) coordinated with Electra flights over western Quebec/James Bay. The impetus for these measurements arise from the aircraft measurements showing MSA/aerosols increasing dramatically off the coast of Alaska during ABLE-3A sampling. One probable source was marine DMS.

Measurements will be designed to characterize plankton source of DMSP and to estimate turnover of key DMSP pools in the water column. I will measure DMS, dissolved and particulate DMSP precursor pools; size fractions of particulate DMSP, pigment analyses, phytoplankton determinations to characterize plankton precursor and calculate soluble DMSP turnover. Cooridination with remote sensing analysis of James Bay /lower Hudson Bay is desired.

I also propose to do some DMSP turnover work in Kinosheo Lakes. This would be coordinated with John Rudd who plans to measure a variety of sulfur species in these lakes in addition to his methane work. Nriagu and Rudd have both found nmol/L concentrations of DMS in freshwater systems with no indication as yet to source.

Methane Investigations

Experiments will focus on the question of plant-mediated transport, probably primarily in Carex habitats. Questions addressed will be related to magnitude, diurnal differences, and relationship to plant architecture.

Gary M. King (Univ. Maine, ME)

The primary effort will involve an analysis of the distribution of methane oxidation rates in several representative habitats. Rates will be assessed in the field using a chamber technique and a combination of one or more inhibitors of methane oxidation, including N-Serv, acetylene, cyanide and nitrogen (for anoxia). A similar approach will be used for cores returned to the lab. Where relevant, the effects of benthic (epiphytic/periphytic) primary production on methane oxidation will be analyzed using a combination of flux and microelectrode studies. Light-dark shifts coupled with inhibitors will be used to determine whether photosynthesis affects emission and to what extent changes in methane oxidation are associated with photosynthesis. Microoxygen electrodes will be used to define the magnitude and location of the photosynthetic effect on methane oxidation; electrodes will also define the zone in which oxic methane consumption occurs. In conjunction with this work profiles of methane will also be examined at 1-2 mm intervals to correlate diffusive fluxes into and out of the oxic zone with observed rates of emission.

An additional effort will involve an analysis of root-associated methane oxidation. A survey of methane uptake by sediment - free roots will be used to determine the diversity of plants with which methane oxidation is associated. Subsequently, one or more of the species thus identified will be used in chamber experiments to assess whole plant rates of oxidation, the relationship between methane concentration and oxidation rates, and the effects of various edaphic factors (e.g. oxygen, light, pH, sulfide, ect.)

Mark E. Hines (U. New Hampshire, NH)

Sulfur gases are important components of the sulfur cycle. They are important in regulating the acidity of precipitation, they are reactive in the atmosphere where they act as chemical reductants and they are important in regulating planetary albedo. Although tremendous progress in determining the natural sources of sulfur gases has been made in the last decade, the role of terrestrial environments as natural sources and sinks of these compounds remains as one of the most uncertain components of the atmospheric sulfur cycle.

Recent studies in my laboratory have shown that Sphagnum bogs and fens can emit relatively high concentrations of reduced sulfur gases into the atmosphere. The gases of interest are dimethyl sulfide (H_3CSCH_3), hydrogen sulfide (H_2S), carbonyl sulfide (OCS), carbon disulfide (CS_2) and methyl mercaptan (H_3CSH). Dimethyl sulfide and H_2S appear to be the predominant sulfur gases emitted from these environments. The characteristics of the production and flux of these gases are largely unknown and the factors which might regulate flux, such as hydrology and temperature are just now being investigated. It appears that these gases originate from anoxic and submerged portions of the decaying peat rather than from the photosynthetically-active areas of the bog.

To investigate the emissions of sulfur gases further we plan to conduct a project in Schefferville which encompasses 1) measurements of emissions directly using dynamic enclosure techniques; 2) examinations of sulfur fluxes from "rich", "poor" and "intermediate" fens and from sites inhabited by differing vegetation; 3) diel emission measurements to determine temperature and light influences; 4) determinations of the depth distribution of sulfur gases within pore waters of selected fens; 5) measurements of ambient concentrations of sulfur gases at selected sites and on the 30 meter tower to better understand the transport and flux of these gases on a larger scale. All measurements will be made using gas chromatography with flame photometric detection and all samples will be collected using cryotrapping techniques and samples will be transported in teflon loops. Chamber experiments will utilize teflon enclosures with zero air for constant sweep gas. Ambient air samples will be scrubbed free of naturally-occurring oxidants (i.e. ozone) using KOH impregnated filters.

The relative "remoteness" of this site compared to our New Hampshire sites and the variety of fens in Schefferville will allow us to make estimates of the importance of these types of habitats as sources of sulfur on a regional and larger scale basis. A primary goal is to determine if these wetlands are important factors in the sulfur cycle of high latitude areas. A secondary goal is to determine which sulfur gases are primarily involved since each one has a unique role in the sulfur cycle and has widely differing lifetimes in the atmosphere.

Gary J. Whiting (STX Corp., NASA-Langley) & David S. Bartlett (Univ. New Hampshire)

There are two primary goals of the net CO_2 exchange/ remote sensing work: 1) To characterize the seasonal net CO_2 exchange in a variety of plant communities associated with the fen/bog wetland and regions and 2) test the potential of relating net CO_2 exchange to the spectral reflectance of the canopy. We (DSB will not be on site) will attempt to reach these goals in the

Schefferville region during the later part of July and with more extensive seasonal measurements in the Moosonee/Kinosheo region.

We will utilize a chamber system to make net CO_2 exchange measurements over different vegetation types under a diversity of light and temperature regimes. Variation in light levels will be accomplished using opaque films to cover the chamber and also natural light variations due to cloud cover and diurnal change. We will obtain net exchange - PAR relationships from these measurements whereby we can estimate net exchange over a diurnal period by applying a simple model. Temperature variations can be achieved by the use of a portable A/C unit utilized to control temperature within the chamber. We plan to incorporate a net exchange, respiration, light, and temperature relationship into a simple model for estimating net exchange over seasonal periods of time. Areal estimates of exchange will be made from extrapolation of chamber measurements weighted by the characteristic LAI for the region.

Relectance measurements will be made using portable radiometers which simulate satellite-derived multispectral reflectance properties. These measurements will coincide with the net CO_2 measurements and permit a relationship to be established. We propose to develop this relationship for the Canadian transect sites between Moosonee and Kinosheo and for the ridge tundra and fen region near Schefferville.

Collaborative efforts will involve developing a relationship between the net ecosystem production, biomass and methane emissions with BREW and Canadian investigators. Efforts will also be directed toward a comparison of chamber CO_2 exchange estimates with micrometeorological tower measurements.

Ramona Pelletier Travis (NASA -Stennis Space Center)

Primary objective is to obtain remotely sensed data for mapping a variety of subsurface properties as well as land cover conditions in support of other BREW field research investigations for extrapolation of in situ measurements to larger geographical scales.

We will employ an Airborne Electromagnetic (AEM) Profiler (helicopter-borne) to aid in determining such variables as depth of peat, depth of water and water conductivity for a series of transects that will be interpolated to produce 3-D maps of these variables for the geographic regions studied. This data will be merged with other surface-based remotely sensed data to develop a comprehensive picture. This data will be collected in the Moosonee/Kinosheo region and possibly in the Schefferville area.

TM or SPOT remote sensing data, having a high spatial resolution, will be acquired for the Schefferville region and processed to produce a classification scheme identifying the important landcover types significant in gas flux studies. AVHRR data will also be acquired and processed for the Schefferville region and the larger surrounding area including portions of the Canadian Shield.

APPENDIX C

POTENTIAL FLIGHT PLANS FOR FLUX MEASUREMENTS

A significant portion of the joint NASA ABLE-3B/Canadian Northern Wetland Study will feature two atmospheric research aircraft flying coordinated missions for flux measurements of key tropospheric species. The research flights in the Hudson Bay Lowlands (HBL) will also address important objectives related to Global Change, including:

- to quantify actual CH_4 emissions from the HBL and correlate these with environmental variables for temporal extrapolation.

- to make flux measurements of heat, momentum, CH_4, CO, CO_2, H_2O and O_3 at scales which will allow development and testing of techniques for extrapolating chamber and tower measurements to regional scales, i.e., the "Scale-Up Experiment".

- to determine the spatial distributions, sources and sinks of a variety of trace gases and organic acids and relate these to climate variables.

The aircraft are the NASA Electra from Wallops Island, Virginia and the Canadian Twin Otter operated by the National Aeronautical Establishment (NAE) of the NRC in Ottawa.

The NASA Electra will be instrumented to make flux measurements of CO, CH_4, O_3, and H_2O, measurements of other trace species, as well as the distribution of ozone and particulates above and below the flight altitude using a DIAL system.

For the Northern Wetlands Study, the Twin Otter will be configured for flux measurements of CO_2 and CH_4. The instrumentation includes systems to make accurate, real-time wind and gust computations for use with the eddy correlation technique for trace gas flux measurement. The Twin Otter will be based at Moosonee, Ontario from June 25, to July 28, 1990 and will fly about 25 research flights over the HBL.

The four "flux" flights to be flown in the HBL by the Electra will be closely coordinated with coincident flights by the Twin Otter. These flights will be categorized as either "scale-up" experiments or "survey" flights. Portions of these flights as well as others will be used for direct intercomparisons of the measurements made between the two aircraft so that any instrument biases can be identified and resolved.

Initial flights in the HBL will probably be of a survey nature. The nominal pattern shown in Figure C-1 will be flown by the Twin Otter in the vicinity of the tower site. This "grid pattern" can be used to produce contour plots of footprint-corrected fluxes which can be related to surface features. Similar or other survey flights may be flown by the Electra as well as a "structure or budget" flux flight such as illustrated in Figure C-2. Near-simultaneous Twin Otter and Electra flights should enhance the scientific return from these investigations.

The flights focusing upon the "scale-up" problem will require on-site determination of the appropriate flight patterns for the two aircraft. The Electra, with its greater speed and range capabilities, might traverse pattern up to 60 km upwind of the Kinosheo tower site while the Twin Otter pattern is in the more immediate vicinity (approximately 15 km) of the tower. By combining such data with those obtained on previous "survey" flux flights in this same vicinity, a comprehensive study of the transformation and transport of several importance trace species can be obtained.

The NASA Electra, following the activities in the HBL, will then be operated from Goose Bay, Labrador. While at the Schefferville research site, one "survey" and one "structure or budget" flux flight will be made. Operation over the Schefferville site is different from that of the HBL site. Logistically the ferry time has been cut from approximately 1 hour for the HBL site to about 20 - 30 minutes. This will allow a more detailed examination of the turbulent structure of the relevant species. patterns will be centered on the Schefferville site and one will probably be attempted during the morning to examine the development of the local boundary layer.

Due to the inherent channeling of the flow in this region due to the terrain, a survey flux flight will probably be required. Data obtained during this flight will be useful in scaling-up flux measurements made at the tower and ground sites.

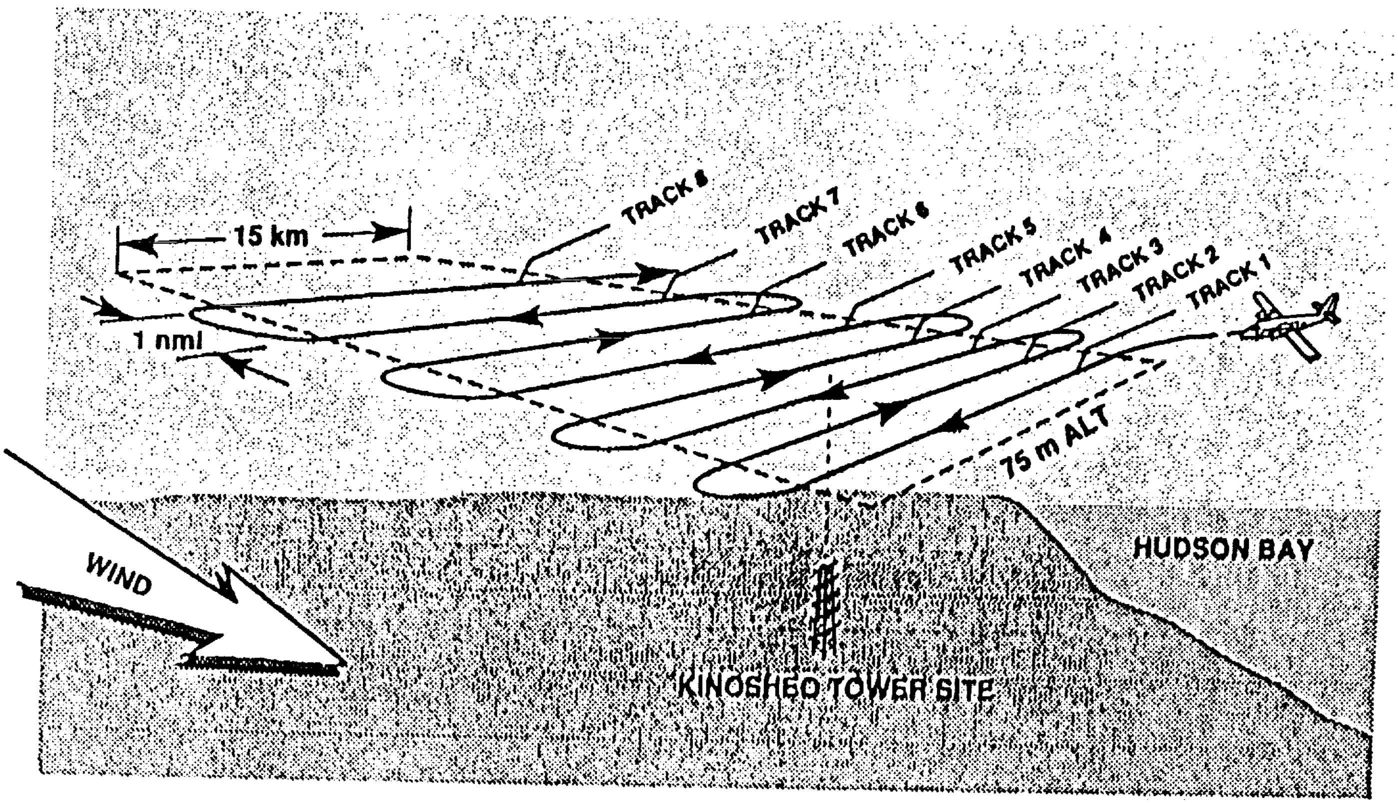

Figure C-1. Twin Otter "Grid Pattern"

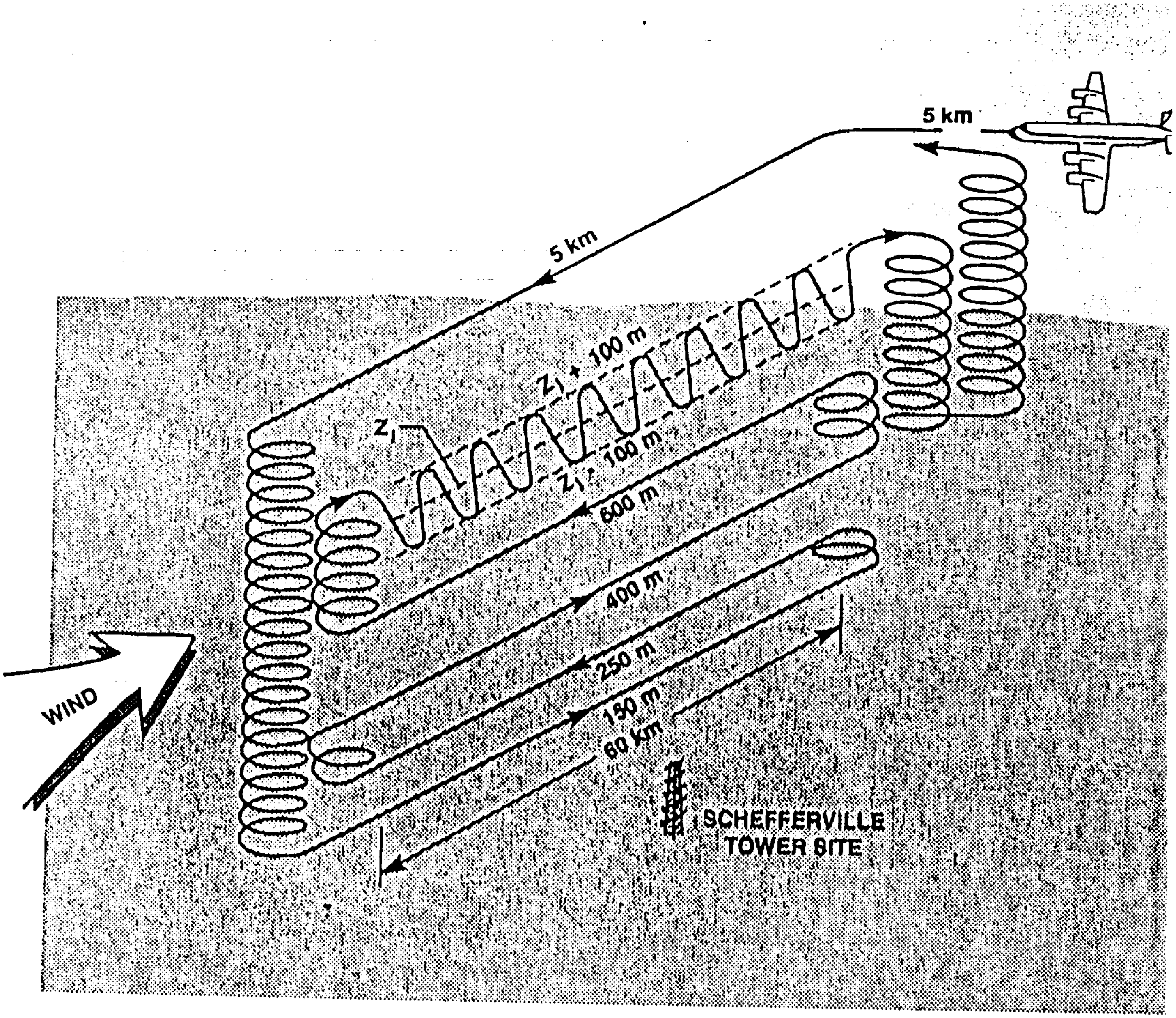

Figure C-2. Boundary Layer Structure Flight

APPENDIX D

INFORMATION CONCERNING SCHEFFERVILLE ACTIVITIES

GENERAL

The McGill Subarctic Research Station is located in the former iron-mining town of Schefferville, in the centre of Nouveau Quebec. Although Schefferville has no road connection to the "outside" it is readily accessible either by daily flights from Montreal or by weekly train service from the town of Sept-Iles located on the North Shore of St. Lawrence River, 550 km to the south. The year-round population of about 1000 inhabitants consists of two Native Bands (Naskapi and Montagnais) and approximately 200 whites. There is a considerable influx of summer visitors - mainly hunters, fishermen and groups involved with mining exploration. The town has all the usual services of small northern community - hotel, post office, grocery store, hardware store, gas station, corner store and medical facilities. Although there is no bank, cheques (preferably in Canadian Dollars) can readily be cashed in town.

The research Station was founded by McGill University in 1954, at the same time as the town of Schefferville was established by the Iron Ore Company of Canada. The Station provides year-round facilities for researchers engaged in studies of the subarctic environment. The Schefferville area is unique in the eastern Subarctic because of the local environmental diversity (geologic, floristic, aquatic and climatic), the 35 year record of research and the road network covering an area of 30 x 80 km which allows ready access to a wide range of sites representing arctic tundra, permafrost terrain, spruce-lichen woodland, spruce-moss forest, peatlands and lakes. The area is within the discontinuous permafrost ozone. The following is an extract from the climatic record (1955-present)

	Mean Temp. (°C)	Rainfall (mm)	Snowfall (cm)	Bright Sunshine (hr)
May	0.9	25.5	26.8	180.0
June	8.4	68.5	7.2	191.2
July	12.4	100.7	0.5	185.8
August	0.9	91.2	2.8	160.3
Annual	-4.9	408.0	382.7	1497.0

Over the past few years the fens have been free of snowcover by 15th May. By this date the lichen-woodland has normally lost 50% of its snowcover. Other climatic information is presented in Figure D-1 (a)-(h).

FACILITIES

The Station can accommodate up to 30 visitors. Laboratory facilities include wet labs, containing spectrophotometers, pH and conductivity meters, ovens, balances, microscopes and a fume hood. In addition, dry lab, and storage facilities are available. Vehicles (boats, trucks, snowmobiles and all terrain cycles) are available for rent. The charge for meals and accommodation is $40.00 (Canadian) per day. Bed linen is provided but hand and bath towels are not. Laundry facilities are available at no extra charge.

FREIGHT

If possible heavy equipment should be shipped from Montreal to Schefferville at least one week in advance of your anticipated arrival date in Schefferville. The suggested routing is by truck from Montreal to Sept-Iles (Cabano Expeditex Inc. - Tel. 514-332-4341) and by weekly train (Quebec, North Shore, and Labrador Railway - Tel. 418-968-7805) from Sept-Iles to Schefferville. As the train leaves Sept-Iles on Thursday mornings, all equipment must reach Sept-Iles by Tuesday of that week to allow for transfer and loading. Shipping documentation must follow ABLE-3B procedures to clear customs.

<u>Never</u> ship by courier companies who use ground transportation for the item will never reach Schefferville and will be "returned to sender".

For those considering bringing a vehicle to Schefferville or personally delivering equipment to the Q.N.S. & L. train station in Sept-Iles, the station staff will normally accept vehicles and materials until noon on the Wednesday, for shipment of the Thursday train (phone for confirmation!). The one-way charge for shipping a pick-up sized vehicle from Sept-Iles to Schefferville is approximately $160.00. Loaded vehicles are normally accepted. For those living in the north-eastern United States a suggested route to Sept-Iles would be through New Brunswick to Matane on the South Shore of the St. Lawrence where a vehicle ferry can be taken to Godbout on the North Shore.

PASSENGER TRANSPORTATION

Air

Schefferville is presently serviced by two carriers.

INTAIR (reservations- Tel. 514-636-3890)	Jet service from Montreal to Wabush. via Quebec and Sept-Iles. Prop. service from Wabush to Schefferville. Presently 4 days per week (Tues.-Fri.) Normally becomes 7 days per week in June. Departure from Montreal 08.00 hrs. Return Ticket cost: $946.00 Excursion Fare cost (book 21 days in advance, stay over at least 1 Sat. night, max stay 30 days) $467.10 Return flight arrives in Montreal at approximately 17.00 hrs.
AIR ALLIANCE/ AIR SCHEFFERVILLE (reservations- 514-393-3333)	Prop. Service Air Alliance - Montreal to Sept-Iles. Prop. Service Air Schefferville - Sept-Iles to Schefferville. Presently 5 days per week (Mon.-Fri.) Normally becomes 7 days per week in June. Departure from Montreal 09.00 hrs. Departure from Sept-Iles 12.15 hrs. Return Ticket cost: $941.80 Excursion Fare cost: $625.00 Return flight arrives in Montreal at approximately 16.00 hrs.

N.B. The above information is currently valid but is liable to change at any time. There is an air war going on between the two groups. Please check with airlines for up-to-date information.

Quebec North Shore and Labrador Railway

The weekly passenger/goods train leaves Sept-Iles for Schefferville at 08.00 hrs. on Thursday morning and normally takes 12-14 hours for the northbound trip. It returns to Sept-Iles at 08.00 hrs. on Friday and takes approximately 12 hours for the south-bound run. The fare is approximately $50.00 each way, with a return ticket saving a couple of dollars. This rather slow, old-fashioned train is an interesting way to see the variation in terrain from the boreal forest to the tundra.

Air/Train

A combination of travel by air from Montreal to Sept-Iles (please note there is no train from Montreal to Sept-Iles) and by weekly train from Sept-Iles to Schefferville is feasible. It takes approximately 30 hours and involves overnighting in Sept-Iles. Travelling by Excursion Air fare from Montreal to Sept-Iles, the total return trip including hotel accommodation, meals and taxis is about the same as travelling Intair Excursion fare from Montreal to Schefferville.

A Selection of Hotel Accommodation in Sept-Iles

Auberge des Gouverneurs.	Approx. $70.00 per night. Modern complex on main street. Close to most facilities.
Hotel Sept-Iles.	Approx. $70.00 per night. On waterfront next to wharf. In older section of town.
Les Mouettes.	Approx. $35.00 per night. On main street. Close to most facilities.
Journey's End.	Approx. $35.00 per night. Adjacent to Les Mouettes. New.
Hotel/Motel Carmello	Approx. $20.00 per night. Popular with students and budget-minded. Cheap, clean and simple. Within walking distance of train.

SUPPLIES AND SERVICES

Schefferville is typical of many small northern towns in that goods and services one would not expect to find are available but certain basic commodities just cannot be found. For example, a VCR can be readily purchased but a certain size of nail is probably "on the next train"! However, these problems can be overcome with a little planning and forethought. Items ordered from Sept-Iles or Montreal can be shipped on the next train or, in the case of any emergency, can normally be air-freighted the following day. Standard spare parts for electronic and field equipment, including fuses, should be brought with you.

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

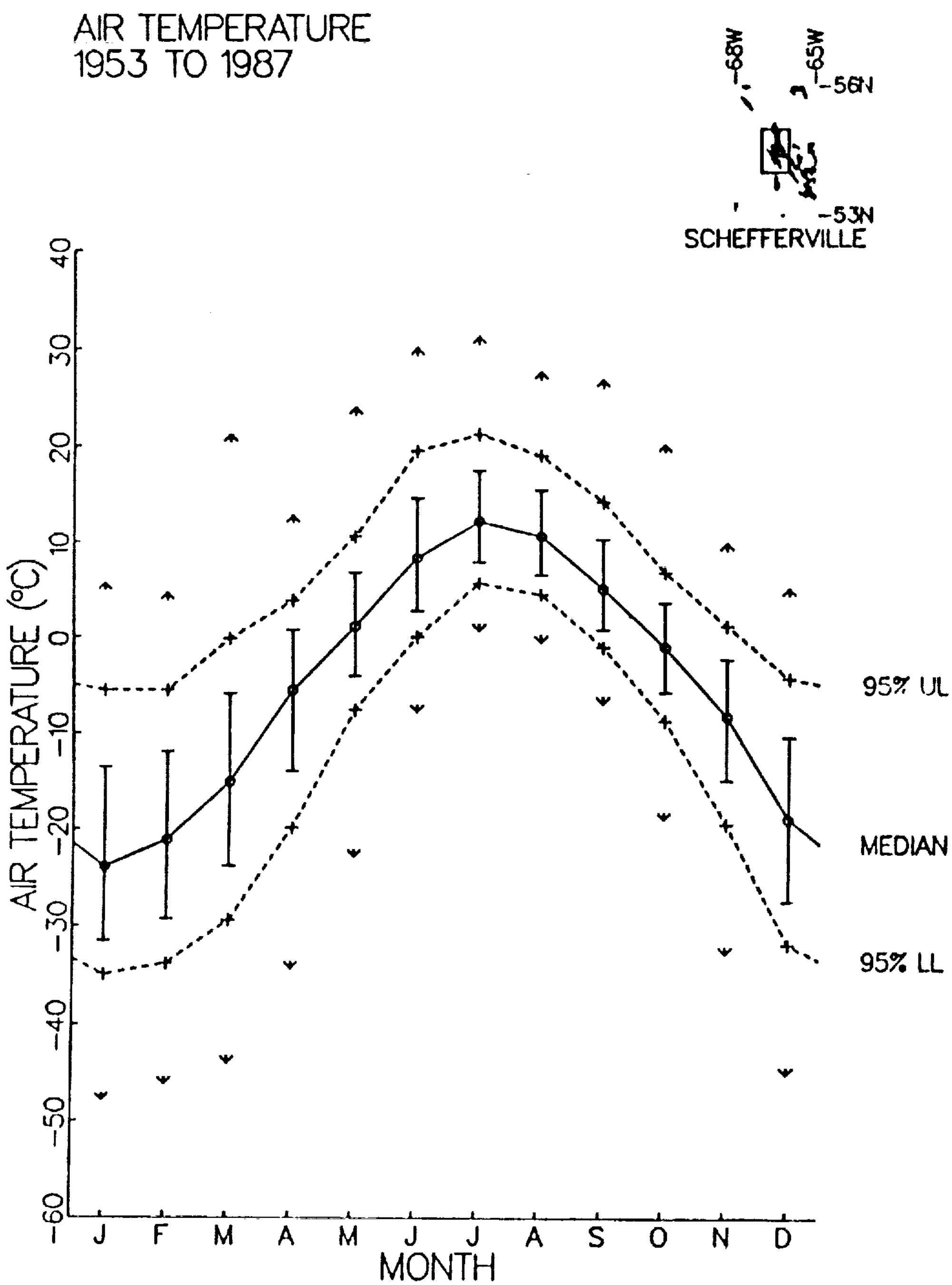

Figure D-1 (a)

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT
CANADIAN CLIMATE CENTRE

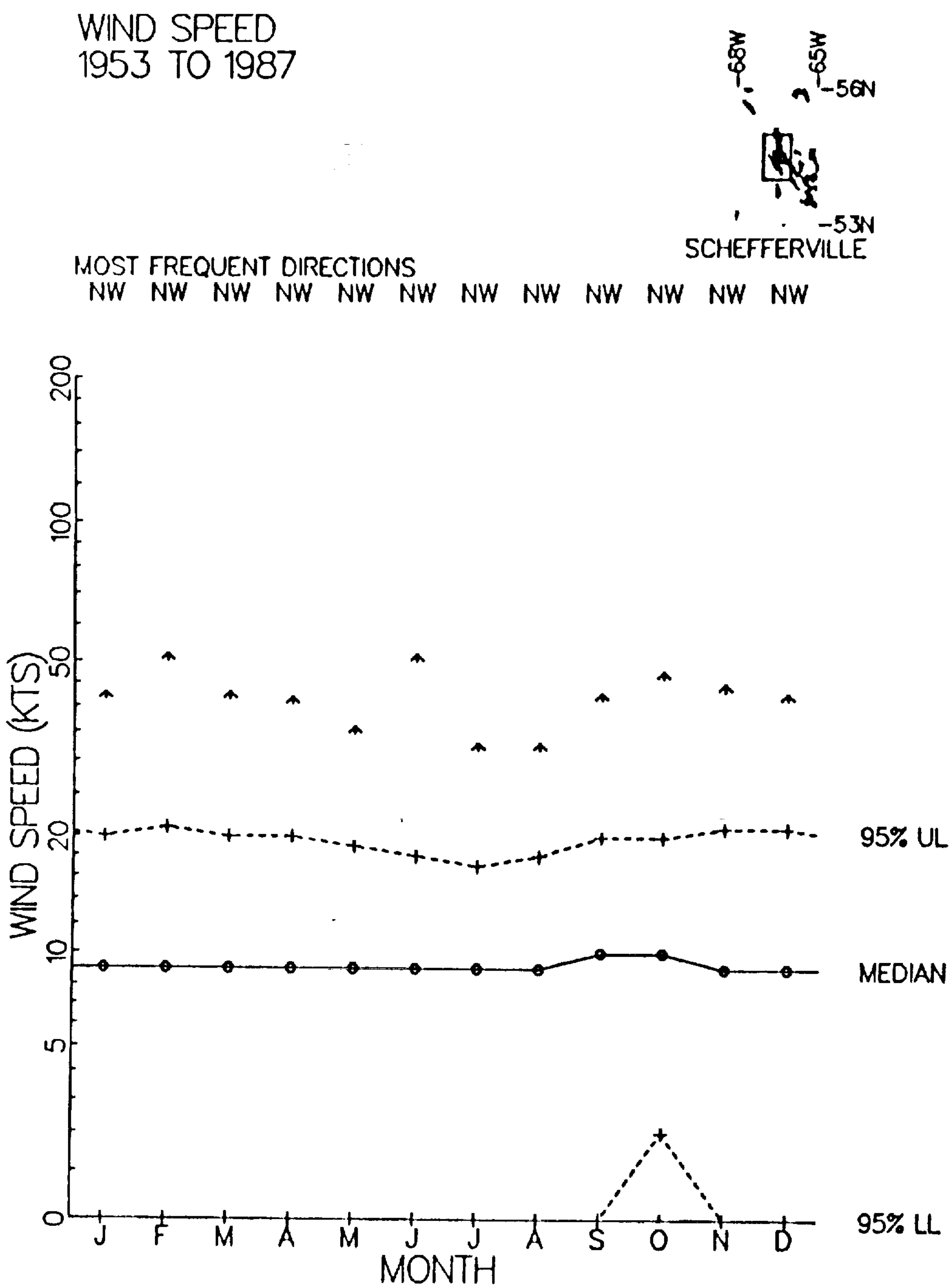

Figure D-1 (b)

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

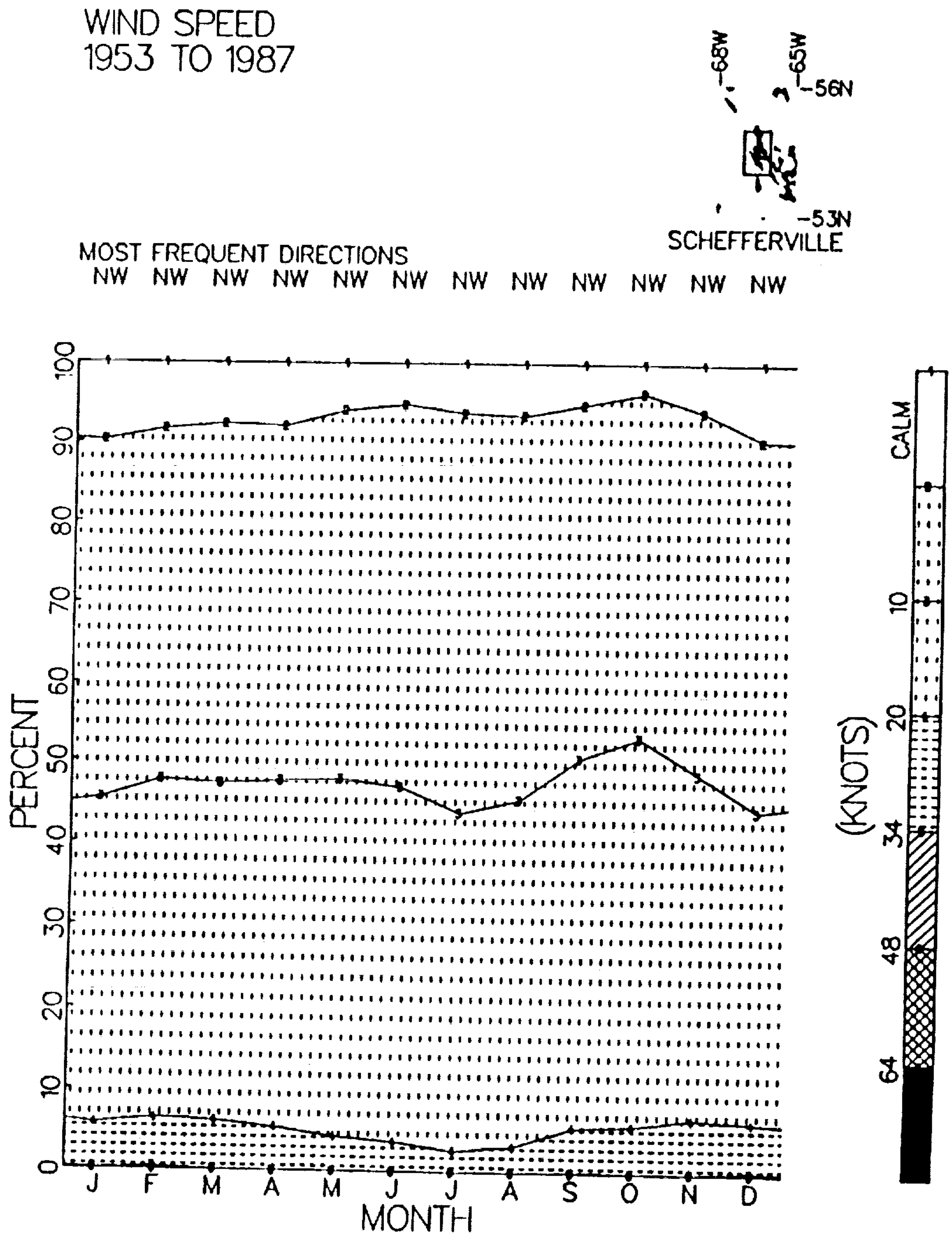

Figure D-1 (c)

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

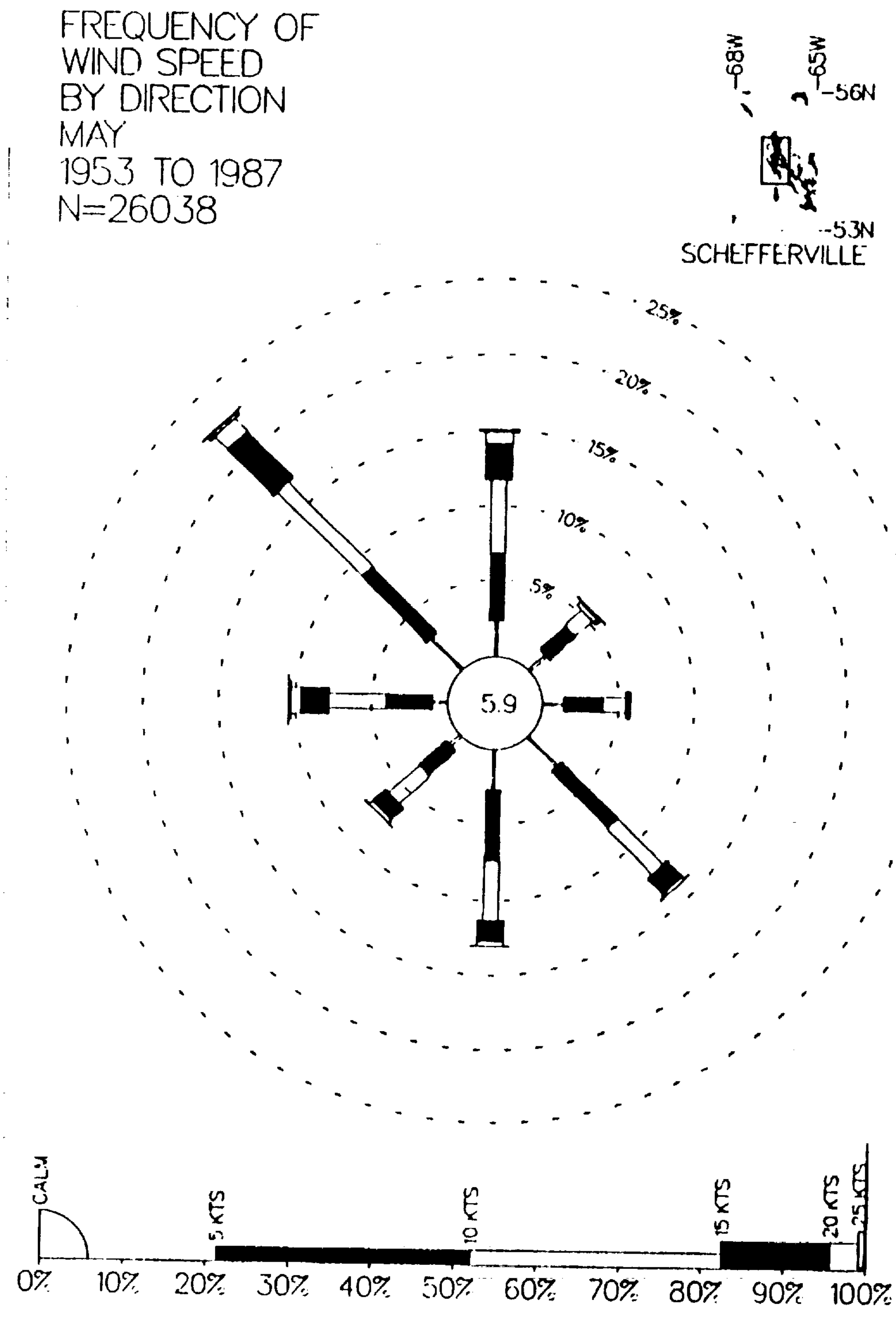

Figure D-1 (d)

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

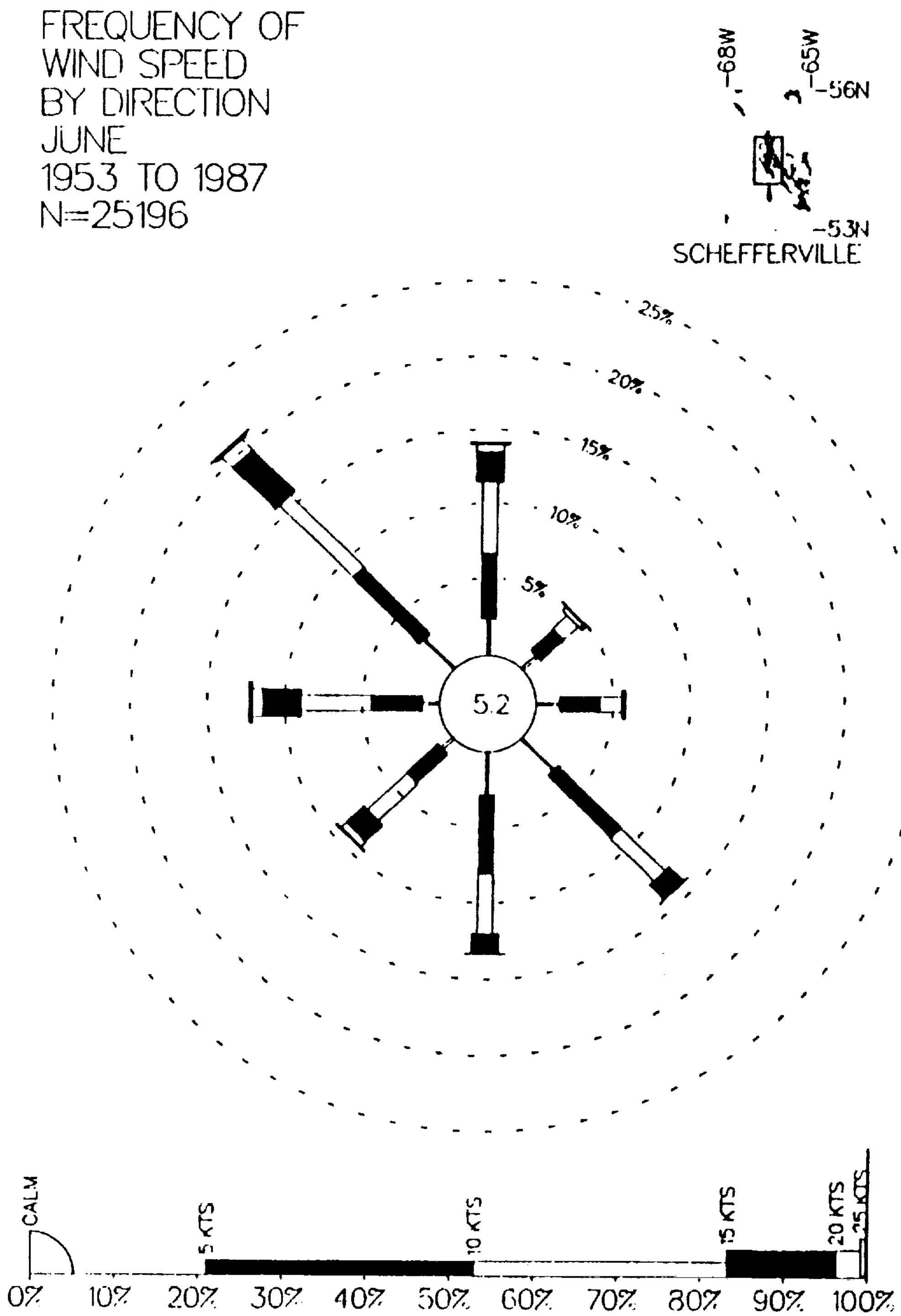

Figure D-1 (c)

FREQUENCY OF
WIND SPEED
BY DIRECTION
JULY
1953 TO 1987
N=26015

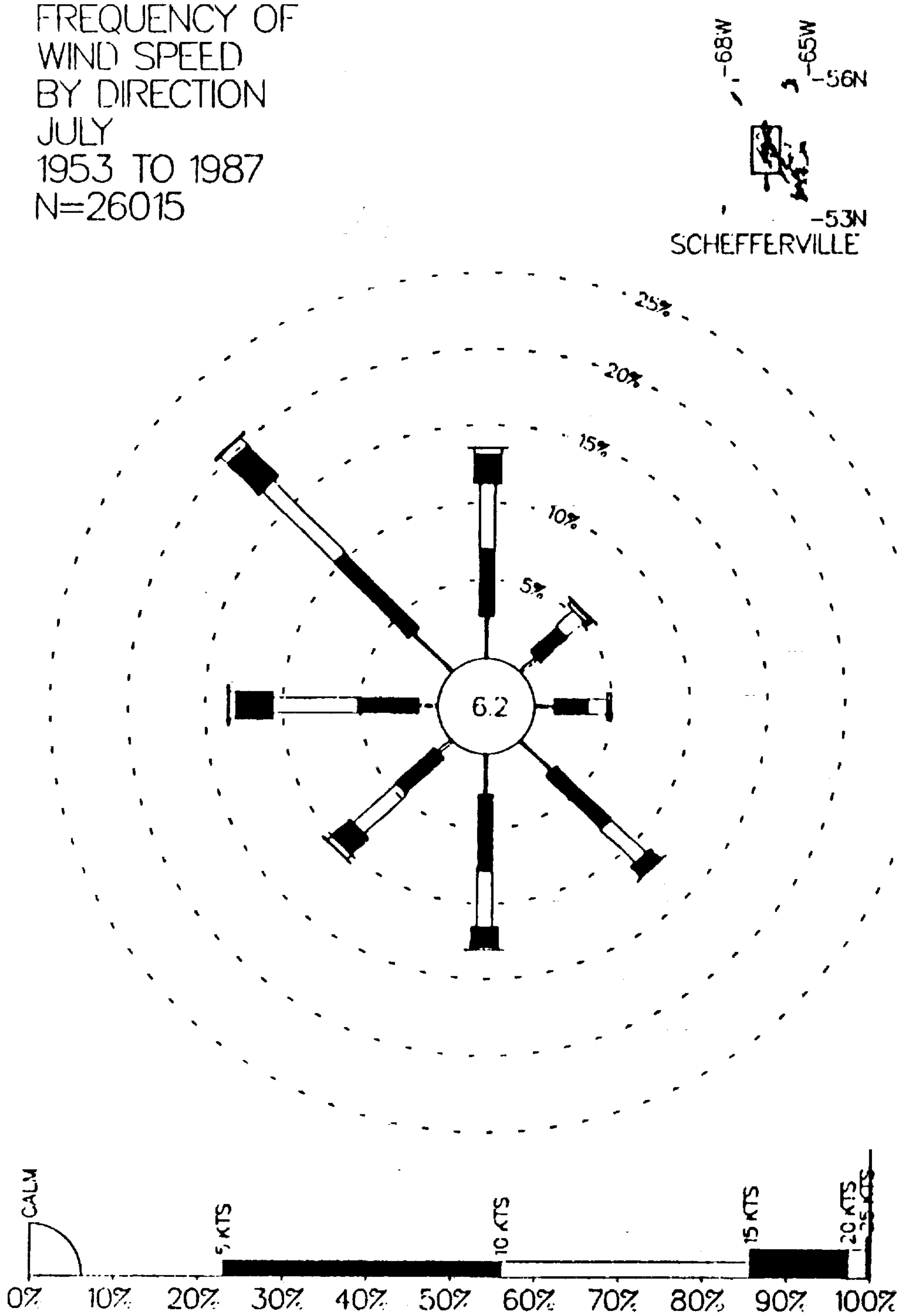

Figure D-1 (f)

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

FREQUENCY OF
WIND SPEED
BY DIRECTION
AUGUST
1953 TO 1987
N=25989

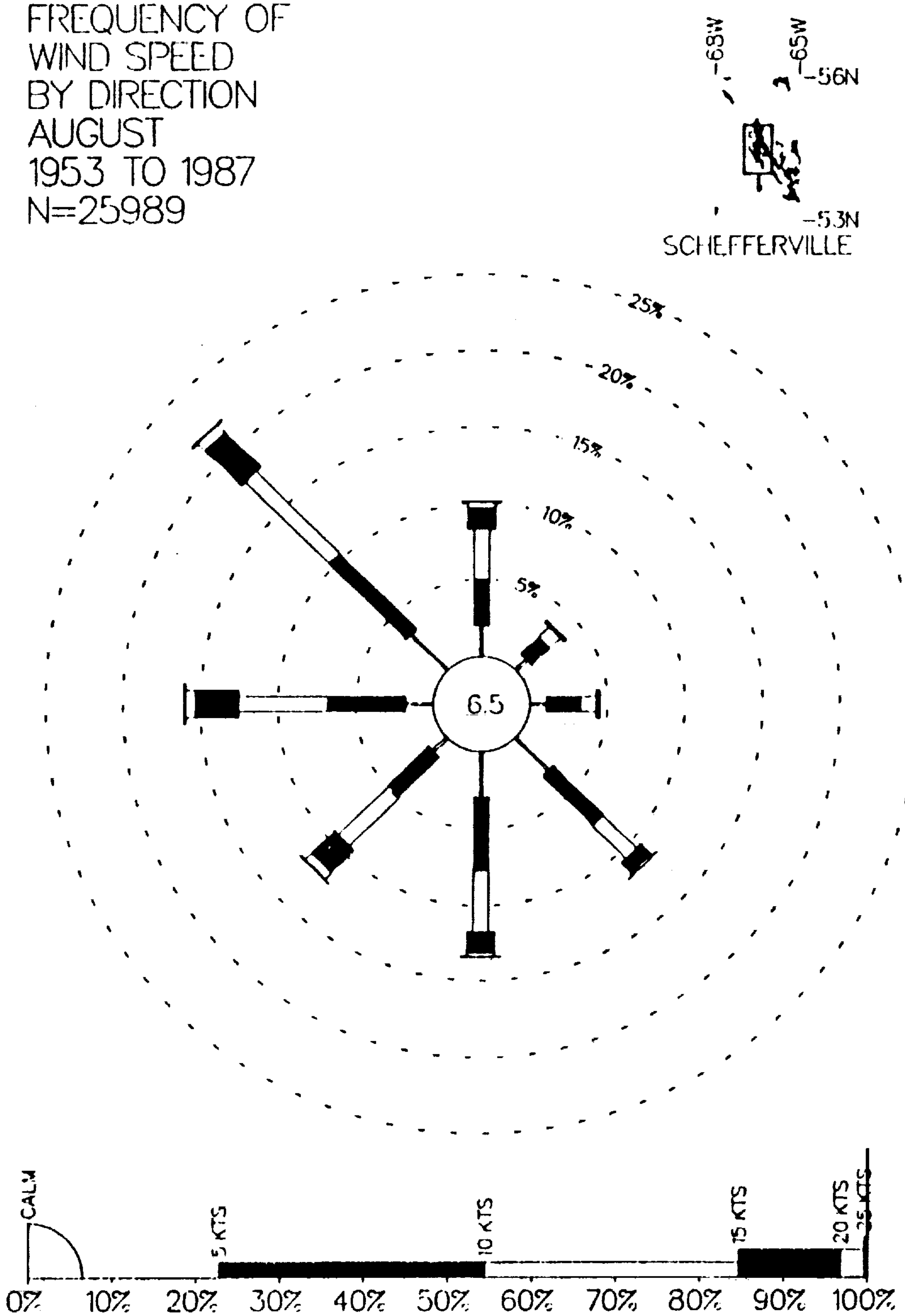

Figure D-1 (g)

ENVIRONMENT CANADA
ATMOSPHERIC ENVIRONMENT CANADIAN CLIMATE CENTRE

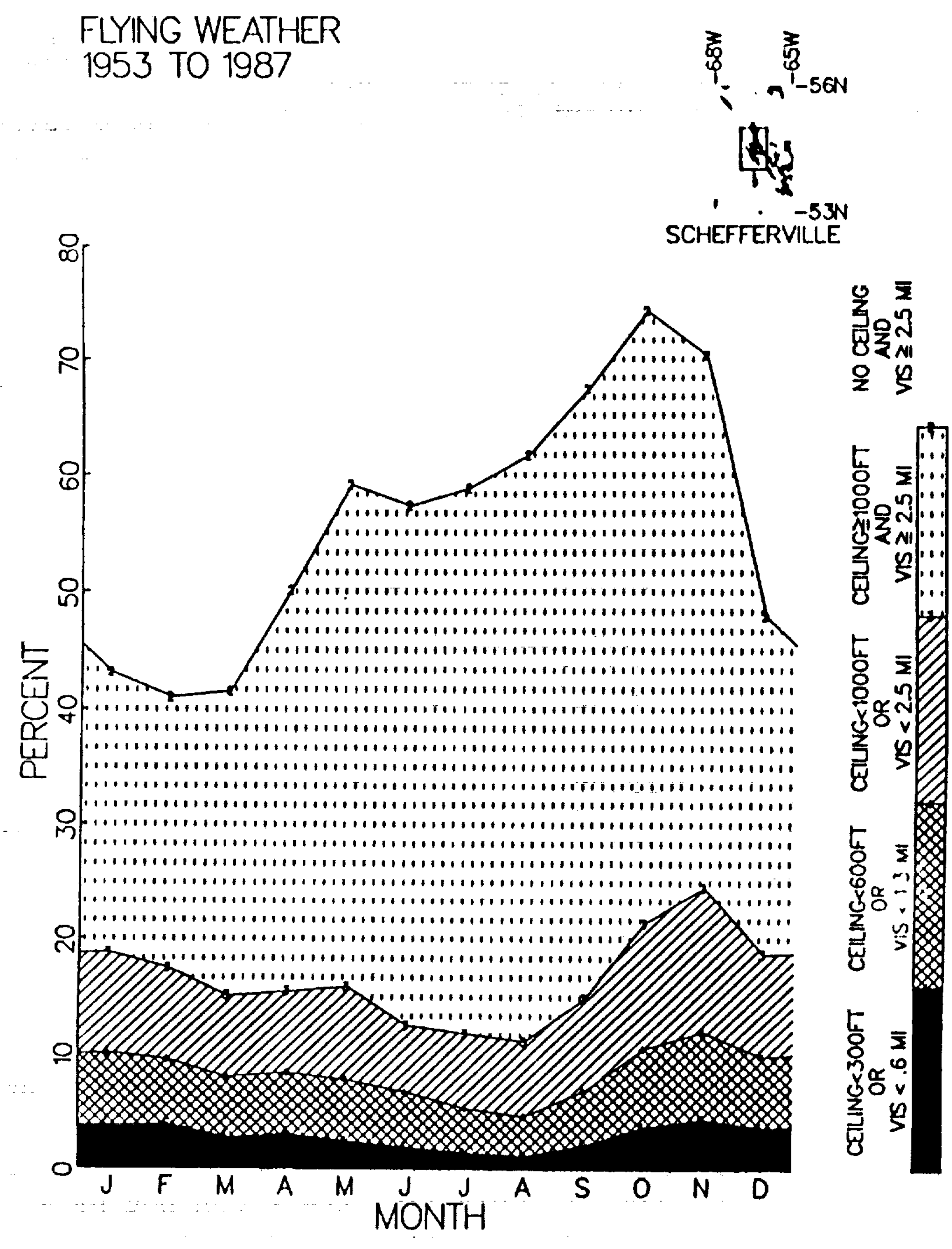

Figure D-1 (h)

APPENDIX E

GTE/ABLE 3B DATA ARCHIVE FORMAT

I. GENERAL INSTRUCTIONS

Data should be submitted to the GTE Data Archive on IBM-compatible disks (5.25" or 3.5", high or low density), or via electronic data transfer, ie. **NASAMAIL**. Other media, such as 9-track tape, while being acceptable, should be avoided except in the case of very large datasets. All non-standard media must be approved by the GTE Data Archive Office prior to submission to the Archive. Data may be submitted as either ASCII-standard files or as Lotus 1-2-3 .WK1 files. Unless approved in advance with the GTE Data Archive Office, data submissions should follow the **GTE Data Archive Protocol**, as described below.

GTE Data Archive Protocol

II. IBM-COMPATIBLE DISK FORMAT

File Organization

The data should be submitted as a single file per flight. If the amount of data exceeds the disk size, the flight should be continued on subsequent disks, with header information repeated and the disk count incremented. (**Note:** This does not constitute a continuation file in the PC or MS DOS sense, but rather two distinct files). The file names should reflect that they are segments of the same flight. The data file naming convention for ABLE 3B is as follows:

NNNNDLXX where:

- NNNN = 4-digit character code for PI
- D = Disk #: Depends upon the number of disks for this flight. Disk 1 has the extension 1, disk 2 = 2, etc.
- L = Location code : (to be supplied by the Project Office) An Example might be:
  - E : Electra
  - T : TREED tower, Schefferville
- XX = 2-digit numeric code descriptor (to be supplied by the Project Office). For a flight, XX = flight number; for ground-based data, this may be a sample number.

NOTE: Each landing constitutes a new flight. Flights are named by sequential numerals only (ie. there can not be a flight named 21A or 21.1). If there are several flights on a day, each flight will receive a separate numeric identifier.

Example:

GTNO1E01 : Ga Tech NO data for Electra Flight 1, the first data file for that flight. (There may be several disks for that flight)

NM102E05 : Project Navigational/Meteorological 10-second data for Electra Flight 5, the second disk in a multi-disk set.

The 4-digit PI identification codes, as well as the Location codes, will be supplied by the GTE Data Management Office prior to start of the Expedition.

Header Format

The header should supply the information needed to read and comprehend the data file. The **GTE Format Specification** contains a detailed description of the header format which should be part of each data file submitted to the archive. Though this may be a restrictive protocol for some investigators, it is felt that complying with the format will ensure that each investigator's data can be read and understood by the archivist and other investigators. Exceptions to the protocol will be handled on a case-by-case basis by the GTE Data Archive Office.

Data Format

This is dictated by the specifications in the Header Format. Note that the **GTE Format Specification** requires that scale factors and offsets be submitted with all data, such that

DataValue * ScaleFactor + Offset = Engineering Units

It is preferable that Scale Factors and Offsets be selected such that the data are represented by whole numbers (see **GTE Format Specification**, lines 13,14). All data or data blocks are to be time tagged. This is done by including both the Julian day of the year and the elapsed seconds of the day (GMT) as the first and second data elements of each record. If a flight crosses midnight GMT, the Julian day of year is incremented and the time resets to 0. All bad or missing data must be filled with a numeric value outside of the standard data range, such that

MissingData * ScaleFactor = Actual Missing Data Value

(see **GTE Format Specification**, line 15)

GTE Format Specification

Line	Description
1:	Number of lines in the header (including blank lines)
2:	Experimenter name and Institution (Last Name, First Name, Institution)
3:	Instrument and/or Technique
4:	Disk Number, Total number of disks for this flight (separated be one or more blanks)
5:	Expedition Name
6:	Flight Start Date (YY MM DD); Data Revision Date (YY MM DD)
7:	Mission Flight Number
8:	Number of Variables (nv)
9:	Number of Comments Lines (nc)
10:	Data sampling interval, delta T, in seconds
11:	Number of samples per time hack (Recommend 1)
12:	Number of lines per sample (Recommend 1)
13:	Scale factors for converting data to Engineering Units. Put these on one line, separated by a space.
14.	Offset values for converting data to Engineering Units. Put these on one line, separated by a space.
15:	Missing data value for each variable, such that

MissingData * ScaleFactor = Actual Missing Data Value

Put these values on one line, separated by a blank. Each value must be well outside of the normal data range. Unless inappropriate, use 9's for these values (ie. range of variable is -.05 to +.05 and a Scale Factor of .01 is used, use 999 for missing value, so that 999 * .01 = 9.99 actual missing data value).

16:	Name of Data Var(1); Units for Var(1)
16+1:	Name of Data Var(2); Units for Var(2)
16+(nv-1):	Name of Data Var(nv); Units for Var(nv)
16+nv:	Comments line 1 (as specified in Line 9)
16+nv+nc:	First data record

Sample GTE Data Submission - ASCII

Line	Data	Comments
1	**26**	*Number of lines in header*
2	**Barrick, John, LaRC**	*Last Name, First Name, Institution*
3	**Nav/Met Data**	*Data Instrument/Technique*
4	**1 2**	*Number of this disk, Total disks for the flight*
5	**ABLE 3B**	*Expedition Name*
6	**90 07 14 90 10 11**	*Mission start date, Data revision date*
7	**5**	*Flight Number*
8	**10**	*(nv) - Number of Variables*
9	**2**	*(nc) - Number of Comments Lines*
10	**10**	*Data sampling interval (seconds)*
11	**1**	*Number of sample per time hack*
12	**1**	*Number of lines per sample*
13	**1 1 .001 .001 1 .1 .1 .1 .001 .001**	*Scale factors (Data * Scale + Offset = Engineering Units)*
14	**0 0 0 0 0 0 0 273.16 0 0**	*Offset values (Data * Scale + Offset = Eng. Units)*
15	**999 99999 999999 999999 99999 9999 9999 9999 99999 99999**	*Null value = Null * Scale*
16	**Day of Year; Julian day**	*Var(1) name; units*
17	**Time; GMT(Elapsed seconds)**	*Var(2) name; units*
18	**Latitude; Degrees East**	*Var(3) name; units*
19	**Longitude; Degrees West**	*Var(4) name; units*
20	**Baro Altitude; Feet**	*Var(5) name; units*
21	**Static Air Temp; Deg C**	*Var(6) name; units*
22	**Dew Point 300; Deg C**	*Var(7) name; units*
23	**Potential Temperature; Deg K**	*Var(8) name; units*
24	**UV Zenith; mW/cm^2**	*Var(9) name; units*
25	**UV Nadir; mW/cm^2**	*Var(10) name; units*
26	**Data recorded at 1 Hz. Values shown 10-second averages, time is median time of average**	
27	**period. DP300 off scale at -20 Deg C.**	*2 lines of comments*
28	**41 86380 999999 999999 24 70 -26 72 -5 -6**	*1st data line*
29	**41 86390 37945 -75472 148 66 -25 65 -5 -6**	*2nd data line*
30	**42 0 37945 -75485 360 56 -26 75 -5 -6**	*3rd data line*

Actual Engineering Units from lines 28-30 above

	DOY	*TIME*	*LAT*	*LONG*	*ALT*	*SAT*	*DP*	*THETA*	*UV Z*	*UV N*
28	**41**	**86380**	**999.999**	**999.999**	**24**	**7.0**	**-2.6**	**280.36**	**-.005**	**-.006**
29	**41**	**86390**	**37.945**	**-75.472**	**148**	**6.6**	**-2.5**	**279.66**	**-.005**	**-.006**
30	**42**	**0**	**37.945**	**-75.485**	**360**	**5.6**	**-2.6**	**280.66**	**-.005**	**-.006**

Sample GTE Data Submission - Lotus 1-2-3

Row	A	B	C	D	E	F	G	H	I	J	
	A	B	C	D	E	F	G	H	I	J	
1	26				*Number of lines in header*						
2	Barrick		John	LaRC	*Last, First, Institution*						
3	Nav/Met Data			*Data Instrument/ Technique*							
4	1	2		*Number of this disk, Total disks for the flight*							
5	ABLE 3B			*Expedition Name*							
6	90	07	14	90	10	11	*Mission start date, Data revision date*				
7	5			*Flight Number*							
8	10			*(nv) - Number of Variables*							
9	2			*(nc) - Number of Comments Lines*							
10	10			*Data sampling interval (seconds)*							
11	1			*Number of sample per time hack*							
12	1			*Number of lines per sample*							
13	1	1	.001	.001	1	.1	.1	.1	.001	.001	*Scale*
14	0	0	0	0	0	0	0	273.2	0	0	*Offset*
15	999	99999	999999	999999	99999	9999	9999	9999	99999	99999	*Null data*
16	Day of Year; Julian day				*Var(1) name; units*						
17	Time; GMT(Elapsed seconds)				*Var(2) name; units*						
18	Latitude; Degrees East			*Var(3) name; units*							
19	Longitude; Degrees West				*Var(4) name; units*						
20	Baro Altitude; Feet				*Var(5) name; units*						
21	Static Air Temp; Deg C			*Var(6) name; units*							
22	Dew Point 300; Deg C				*Var(7) name; units*						
23	Potential Temperature; Deg K				*Var(8) name; units*						
24	UV Zenith; mW/cm^2				*Var(9) name; units*						
25	UV Nadir; mW/cm^2				*Var(10) name; units*						
26	Data recorded at 1 Hz. Values shown 10-second averages, time is median time of average										
27	period. DP300 off scale at -20 Deg C. *2 lines of comments*										
28	41	86380	999999	999999	24	70	-26	72	-5	-6	*1st data*
29	41	86390	37945	-75472	148	66	-25	65	-5	-6	*2nd data*
30	42	0	37945	-75485	360	56	-26	65	-5	-6	*3rd data*

III. MAGNETIC TAPE FORMAT

A. Industry ANSI standard, 9-track, 1/2 inch wide magnetic tape.

B. Tape density up to 6250 bpi.

C. ASCII (preferred) or EBCIDIC encoding.

D. Fixed block length of 5120 characters or less.

E. Tape written as Stranger Tape (unlabeled).

F. Separate each file with a single EOF mark, double EOF after last file on tape.

G. No multi-tape files allowed.

IV. TELEMAIL FORMAT

80 column ASCII records. If tabs are used, they must be every 10 columns (11,21,31,etc.)

V. ACCOMPANYING DATA PRODUCTS

Each submission to the GTE Data Archive should be accompanied by a hard copy of the data file directory, a sample printout of the data, plus any other information needed to read the data. In the case of magnetic tape, please include a Magnetic Tape Description Form with the data submittal.

MAGNETIC TAPE DESCRIPTION FORM

Complete this form and attach it to the 9-track tape documentation submitted to the GTE Data Archive. Your computer systems people should be able to provide the computer information requested.

Investigator Name : ____________________

Address : ____________________

Tape ID : ____________________

Computer System (e.g., VAX 11/780) : ____________________

Recording Density : ____________________

Recording Mode (e.g., odd or even parity) : ____________________

Number of Logical Records per Physical Record Unit : ____________________

Logical Record Length : ____________________

Physical Record Length : ____________________

Total Files on Tape : ____________________

Provide additional information below : ____________________

APPENDIX F

GTE/ABLE-3B PROGRAM AND PROJECT PERSONNEL

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